Special Report

ANALYSIS OF THE 1988-1989 DROUGHT

by

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Executive Summary

During the period of September 1988 through August 1989 rainfall averaged 40 inches over the entire District, which is 13 inches below normal. This represents a drought return frequency of one in 50 years. This rainfall deficiency was most extreme in the Everglades Agricultural Area (EAA) and the Lower East Coast, which experienced drought return frequencies greater than one in 100 years in the EAA, and greater than one in 50 years in the Lower East Coast. Rainfall was 20 inches below normal in both areas. This rainfall deficiency resulted in an increase in water demand which translated into a large depletion of storage in the region's major reservoirs, Lake Okeechobee and the Water Conservation Areas.

During this drought period, Lake Okeechobee and the Water Conservation Areas had the largest depletion of storage for the months of September through August since the establishment of the Water Conservation Areas in 1963. Lake Okeechobee lost 1.89 million acre-feet of storage during this period and, likewise, the Water Conservation Areas lost 1.15 million acre-feet. The total system storage fell from 6.79 million acre-feet on September 1, 1988 to 3.65 million acre-feet on August 31, 1989, for a total loss in storage of 3.13 million acre-feet. Water Conservation Areas 1 and 2A experienced record low stages during the dry season months and Water Conservation Area 3A (WCA 3A) has had record low levels since the month of June. The increase in demands combined with low stages in the Water Conservation Areas necessitated large releases from Lake Okeechobee to both the EAA and the Lower East Coast.

A total of 790,000 acre-feet was released from the Lake to the EAA for supplemental agricultural demands and a record 310,000 acre-feet went to maintain the Lower East Coast canals at the proper stages and provide recharge to the coastal wellfields. A significant amount of the water delivered to the Lower East Coast was used to keep the canals in the South Dade Conveyance system at the design stages.

During this period, very little water went to Shark River Slough in Everglades National Park (ENP). A total of 230,000 acre-feet was delivered to ENP: 182,000 acre-feet through the S-12 structure and 48,000 acre feet through S-333. During the last nine months, no water has been delivered to the Park in accordance with the rainfall formula. The nine months the S-12 structures were closed during this drought is the longest period these structures were ever closed. ENP and WCA 3A have been under a very severe drought. The rainfall deficiency during this drought, as in the 1980-81 drought, occurred during the wet season months, but the main difference is in the geographical distribution. The 1980-81 drought was extremely severe in the Kissimmee River basin, Lake Okeechobee and the EAA. The 1988-89 drought was District-wide, but was particularly critical in the EAA and the Lower East Coast.

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1. INTRODUCTION

The purpose of this report is to analyze and document the performance of the Central and Southern Florida (C&SF) surface water supply system under the below normal rainfall conditions that existed during the period September 1, 1988 through August 31, 1989. Comparisons with previous droughts are included, as well as projections for the upcoming dry season. Meteorological droughts are defined as extended periods of below normal rainfall conditions. The impact of droughts on water supply is a function of the antecedent conditions, the level of demand and the adequacy of the water supply system to deliver water to the impacted areas.

The surface water supply system in central and southern Florida is part of the Central and Southern Florida Flood Control Project authorized by Congress in 1949 and built during the last four decades. This project as shown in Figure 1-1 interconnects a series of lakes used, in part, as water storage reservoirs with a series of canals that conveys water to the agricultural and urban users.

The heart of the water supply system is Lake Okeechobee, a 730-square mile lake which provides water supply for much of south Florida. The Lake provides water to the Everglades Agricultural Area, portions of the St. Lucie and Caloosahatchee basins, and is also used to maintain canal levels in the coastal reaches of Dade, Broward and Palm Beach County canals, and the South Dade Conveyance System. These deliveries are made during the critical dry months of March, April and May, and/or other times of significant below normal rainfall conditions. In the area supplied from the C&SF project, the level of Lake Okeechobee is the most important indicator of the severity of a drought, and the ability of the water supply system to overcome it.

An important element of the water supply system is the Upper Kissimmee Chain of Lakes (UKL) which includes, among others, Lake Tohopekaliga, East Lake Tohopekaliga, and Lake Kissimmee. The water stored in the UKL is rarely used for water supply in the area surrounding the lakes since the majority of the users in that basin use groundwater as the main source of water supply, but it contributes to the water storage of Lake Okeechobee. Under normal conditions, about 31% of inflow to Lake Okeechobee is from the UKL through the Kissimmee River to Lake Okeechobee on an annual basis. The majority of this inflow occurs during the period of February through May when the regulation schedules of these lakes recede. In addition to the inflow coming from UKL, a significant amount of inflow to Lake Okeechobee comes from runoff in the Kissimmee River Basin. This inflow enters Lake Okeechobee through structure 65E and is, after rainfall, the largest source of water for Lake Okeechobee.

Lake Istokpoga west of the Kissimmee River is a shallow lake with a surface area of 43 square miles that provides water supply for the agricultural and urban users of the Indian Prairie Basin and, on occasions, provides inflow to Lake Okeechobee.

A critical component of the water supply delivery system is the Water Conservation Area (WCA) system which is composed of the three major water storage areas, WCA 1, WCA 2A, and WCA 3A, and two others, WCA 2B and WCA 3B, which are very inefficient for water storage.

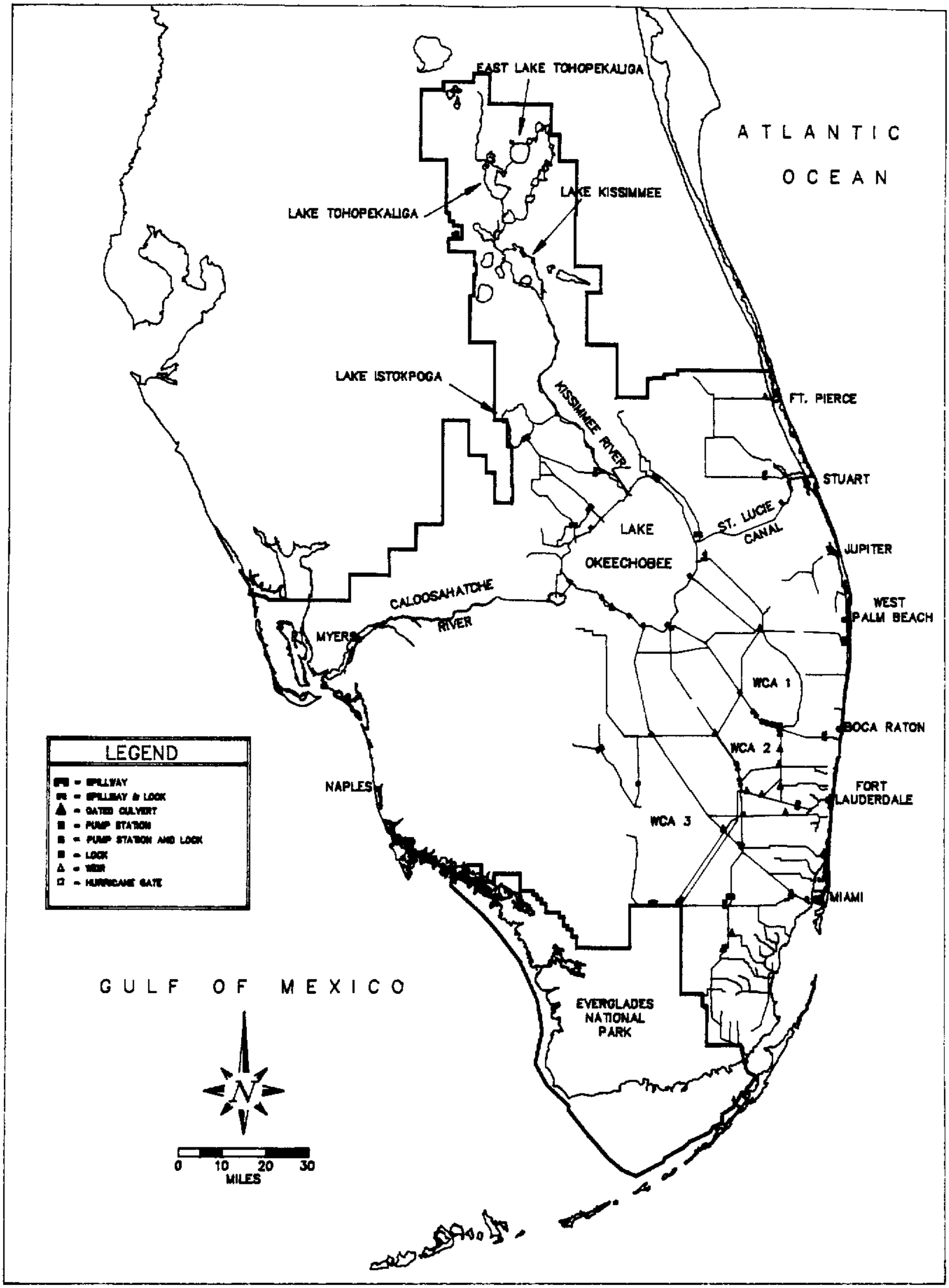

Figure 1-1 Central and Southern Florida Flood Control Project

The Water Conservation Areas were originally part of the Everglades that were converted into water storage areas as part of the Flood Control Project approved by Congress, while preserving their ecological values. Due to the large evapotranspiration rate and seepage, the Water Conservation Areas are generally inefficient for surface water storage during dry periods; their main function is to recharge the surficial aquifer east of these areas known as the Biscayne aquifer which provides the majority of the water supply for the urban population of the lower east coast of Florida. When the storage in these areas subsides, then their recharge capability significantly decreases and the burden of recharging the Biscayne aquifer and preventing saline intrusion to coastal wellfields falls on Lake Okeechobee.

An additional important function of the WCAs, particularly WCA 3A, is to provide sufficient flows to the Everglades National Park (ENP), and North East Shark River Slough (NESRS), to preserve their ecological integrity. The WCAs also provide water supply to the agricultural and urban interests in south Dade through the South Dade Conveyance System either directly or through wellfield recharge.

This report presents an analysis of the rainfall conditions from the period of September 1, 1988 to August 31, 1989, including a comparison with previous droughts. It also includes a water budget of the major reservoirs indicating the water supply distribution on a monthly basis. Finally, it presents the stage/storage projections based on above, below, and normal rainfall conditions for the 1989-90 dry season.

2. RAINFALL DROUGHT FREQUENCY ANALYSIS

In this chapter, District Rainfall is analyzed to quantify the severity of drought during the 12-month period from September 1988 through August 1989. Rainfall in six of twelve basins which comprise the District (Figure 2-1) is also analyzed.

Rainfall averaged 40 inches over the District during this period, about 13 inches below normal. The probability of the District receiving 40 inches or less in the same twelve-month period is approximately 2 percent or 0.02; thus the District experienced a rainfall drought[1] having a return period of 50 years[2]. Rainfall basins (Figure 2-1) within the District have experienced a significant lack of rainfall since September of 1988, with drought return periods often exceeding 100 years. Of the twelve regions (eleven rainfall basins and Lake Okeechobee), the Everglades Agricultural Area (EAA) and the Lower East Coast have experienced the most severe rainfall drought during this period. Estimates of rainfall drought frequencies are reported by basin and comparisons are made with normal rainfall amounts. A summary of drought and normal rainfall appears in Table 2-1. A map and list of gauges used in this analysis appears in Figure 2-10 and inTable 2-2, respectively.

Everglades Agricultural Area

This 800 square mile area adjacent to and south of Lake Okeechobee is highly dependent on rainfall for crop production. The EAA received 32 inches of rainfall from September 1988 through August 1989, the lowest amount of rainfall on record (1928-1929, Figure 2-2). This amount exceeds the 100-year drought (Figure 2-3). The accumulated rainfall deficit during this period was over 20 inches and is attributable to each of the wet-season months having below-normal rainfall. Rainfall through February totaled less than 6 inches, producing drought conditions having a return period greater than 100 years. Rainfall in March and April was above normal, moderating the severity of the drought. Subsequently, below-normal rainfall in four months (May-August) that are typically "wet" added eight inches to the deficit; once again the EAA drought return period exceeded 100 years.

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[1]In this context, the term *drought* refers to a rainfall amount over a specified time that is less than its corresponding normal (mean) amount, The magnitude of a rainfall drought is expressed by a return period of *n* years and is computed as the reciprocal of the probability of exceedance. A rainfall amount is said to have exceeded an *n*-year drought if it is less than the rainfall amount corresponding to the *n*-year drought. Thus, if the probability of a rainfall drought value of being say, 20 inches or less is 1% (0.01) in any given year, then the return period of a 20-inch rainfall is 1/(0.01) or 100 years. This means one would expect 20 inches of less *on the average* once every 100 years. An event having a 100-year return period is also referred to as a 1%-chance event.

[2]A return period is used in lieu of percentage-of-normal when reporting the magnitude of a rainfall drought. One advantage is that it takes into account more characteristics of the historical rainfall (mean avalue and variance).the percentage-of-normal Also a desirable characteristic is that the indication of drought severity by return period is invariant with time and location. By definition, a 100-year rainfall drought will occur on the average, once every 100 years, regardless of which area or how many months are being analyzed. In contrast, 50 percent of normal rainfall for one month is not necessarily as severe as 50 percent of normal rainfall for twelve months. For similar reasons, rainfall from different areas reported in terms of return period can be directly compared whereas if reported in terms of percentage of normal, comparison is less precise.

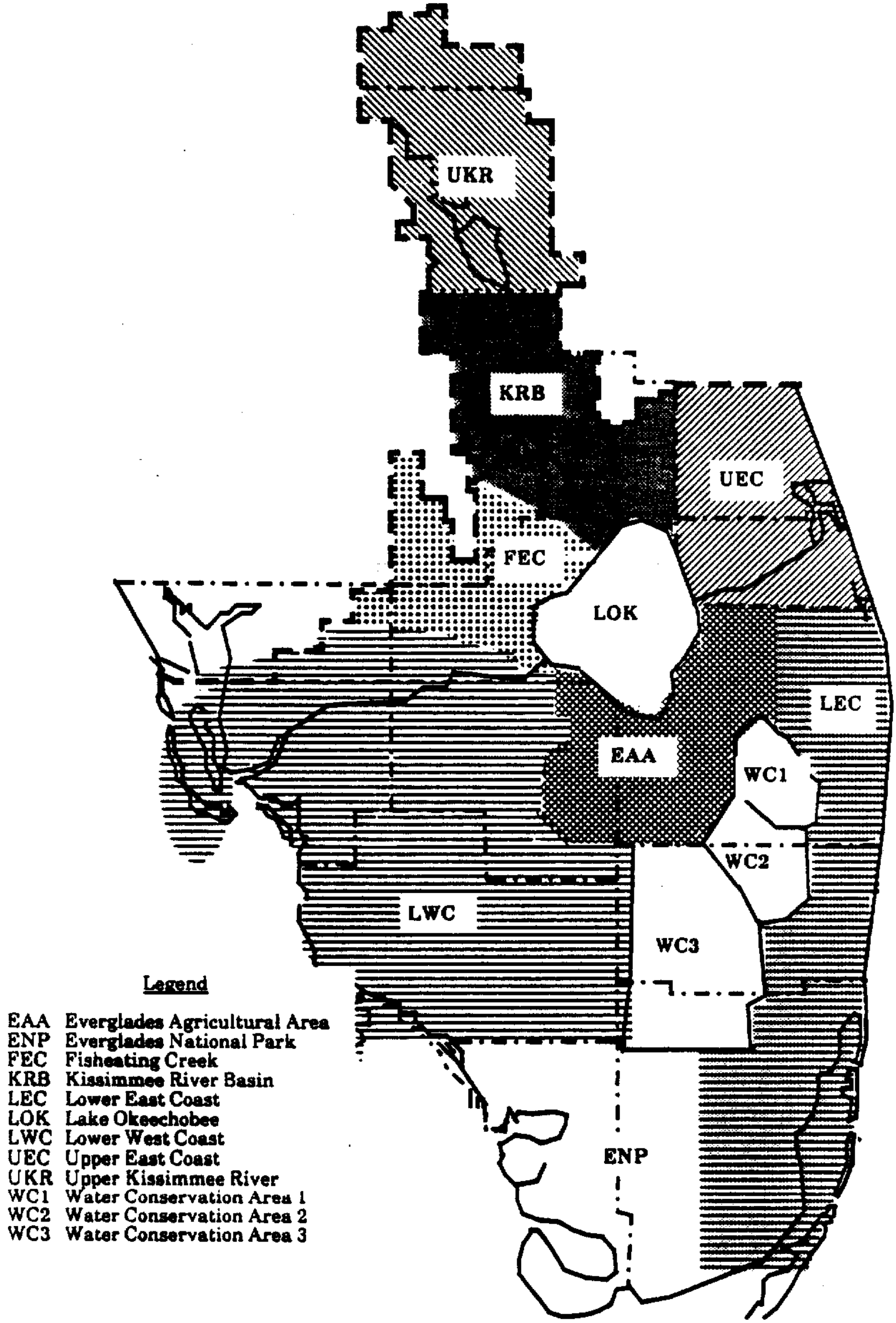


Figure 2-1 SFWMD Rainfall Basins

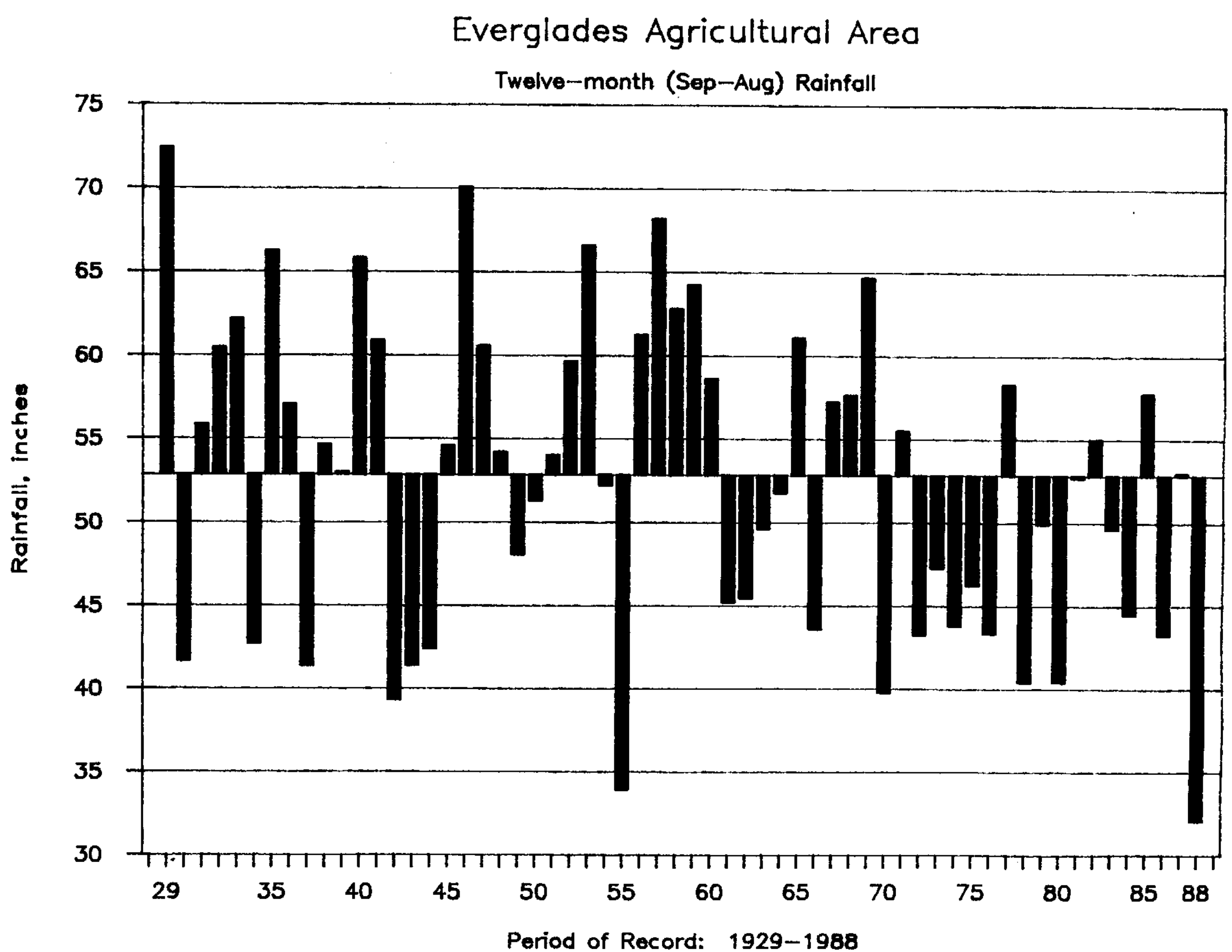


Figure 2-2 Everglades Agricultural Area 12-Month (Sept. Aug.) Rainfall

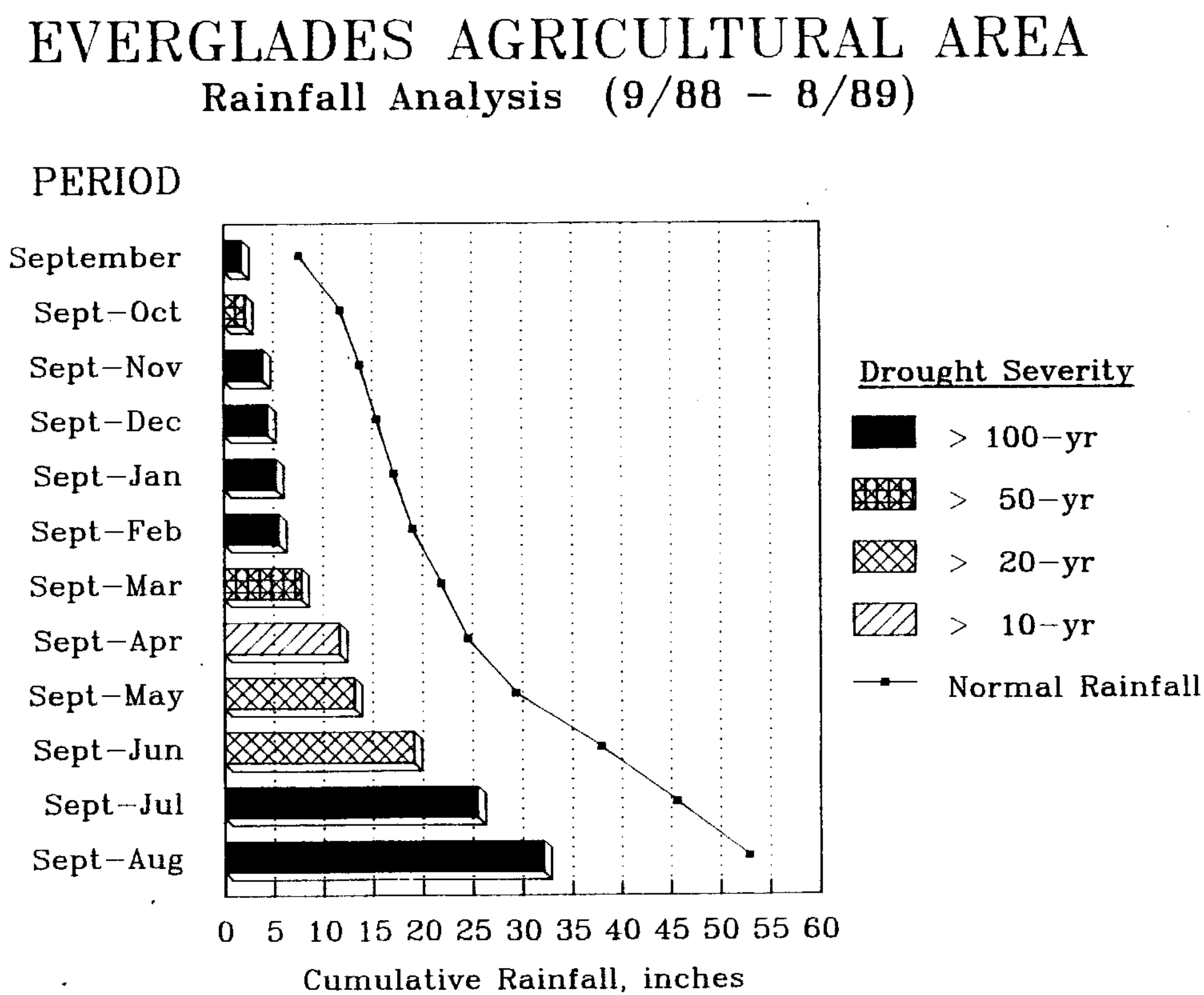


Figure 2-3 Everglades Agricultural Area Rainfall Analysis (9/88 8/89)

TABLE 2-1. 1988-1989 Drought Rainfall versus Normal Rainfall (inches)

Month	Everglades Agricultural Area		Lower East Coast		Lower Kissimmee		Lake Okeechobee		Water Conservation Area 3		Everglades National Park	
	88-89	Avg	88-89	Avg	88-89	Avg	88-89	Avg	88-89	Avg	88-89	Avg
September	1.8	7.6	2.2	8.4	3.0	7.0	1.2	5.7	2.0	5.7	5.2	8.8
October	0.4	4.2	2.0	7.7	1.1	3.6	0.7	3.7	1.1	3.5	1.6	4.9
November	1.8	2.0	2.3	3.0	2.9	1.7	3.2	1.6	1.5	2.0	1.3	1.9
December	0.5	1.7	0.9	2.0	1.7	1.6	0.9	1.5	0.3	1.4	0.3	1.4
January	0.8	1.7	0.9	2.4	2.1	1.9	1.0	1.7	1.1	1.5	0.9	1.6
February	0.3	1.9	0.8	2.1	0.7	2.3	0.3	2.0	0.1	1.7	0.2	1.7
March	2.3	1.9	2.2	2.8	3.5	2.8	2.7	2.7	1.5	2.3	0.9	1.9
April	3.8	2.6	4.2	3.4	3.6	2.6	4.9	2.1	2.9	1.9	2.7	2.3
May	1.5	4.8	2.1	5.8	2.4	4.2	1.8	4.4	2.5	4.4	2.5	5.4
June	5.3	7.6	7.3	8.1	5.5	7.5	4.3	6.8	4.9	7.9	8.8	9.4
July	6.4	7.7	6.0	6.8	7.3	7.8	4.8	6.5	6.9	6.6	*8.4*	8.1
August	6.6	7.3	7.1	6.8	7.5	6.8	5.6	5.9	7.8	6.0	*10.0*	7.7
TOTAL	32	53	38	59	41	50	31	45	33	45	*43*	55

Rainfall values in *italics* are provisional.

Average monthly values are based on the following number of years of record for each basin:

Everglades Agricultural Area	60
Lower East Coast	74
Lower Kissimmee	74
Lake Okeechobee	37
Water Conservation Area 3	26
Everglades National Park	48

Lower East Coast

The Lower East Coast (LEC) is 1920 square miles in size and essentially consists of eastern Palm Beach, Broward, and Dade counties. Rainfall for the twelve-month period ending August 1989 was 38 inches, more than twenty inches below normal (Figure 2-4). It was among the four lowest LEC twelve-month (September-August) rainfalls on record (Figure 2-5), each of which recorded less than 40 inches. Just over two inches fell in September then in October, a total of 12 inches below normal for the two months. A significant rainfall drought persisted. Each of the cumulative rainfall amounts through March was the lowest on record (75 years). Near-normal rainfall during the wet-season months of June, July, and August of 1989 (recorded 20"; mean of 21") did not have a significant effect of reducing the LEC rainfall drought magnitude.

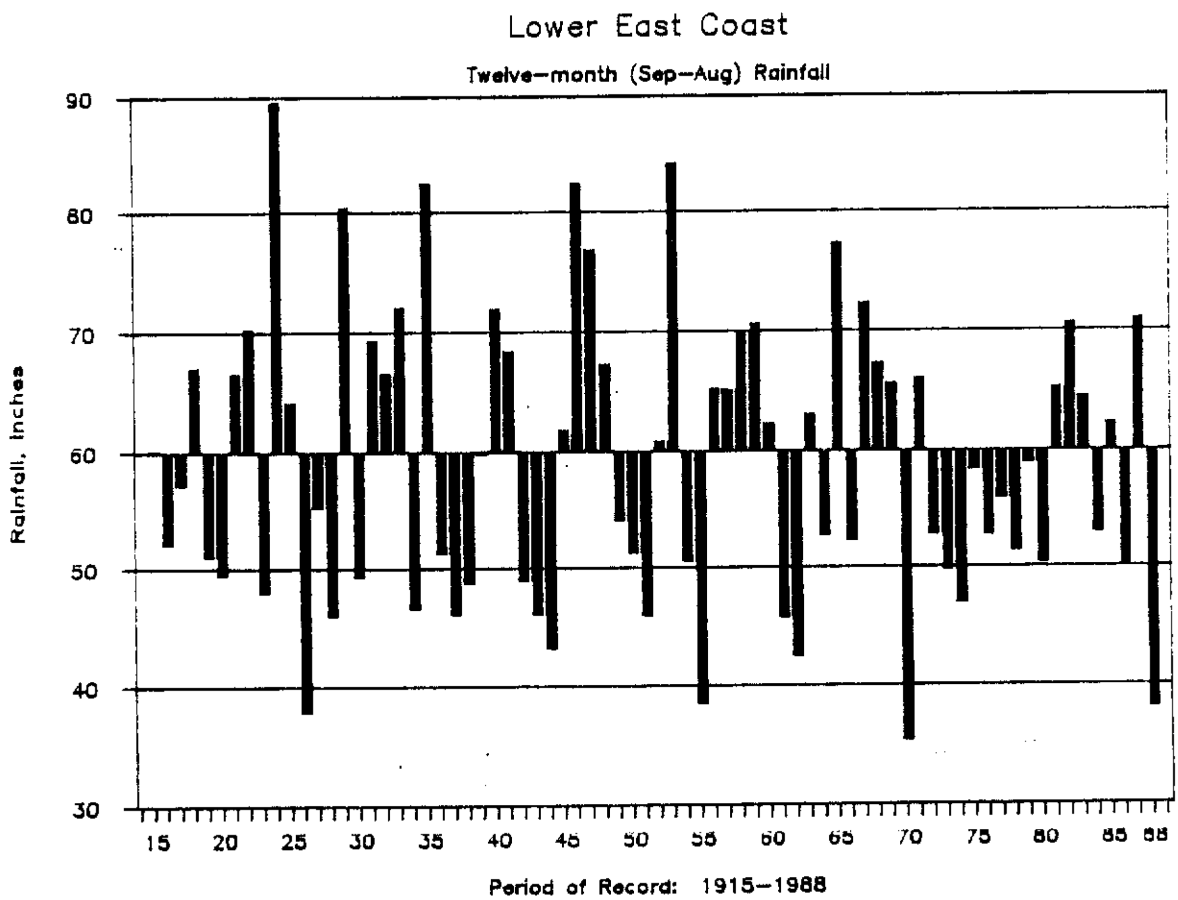


Figure 2-4 Lower East Coast 12-Month (Sept.-Aug.) Rainfall

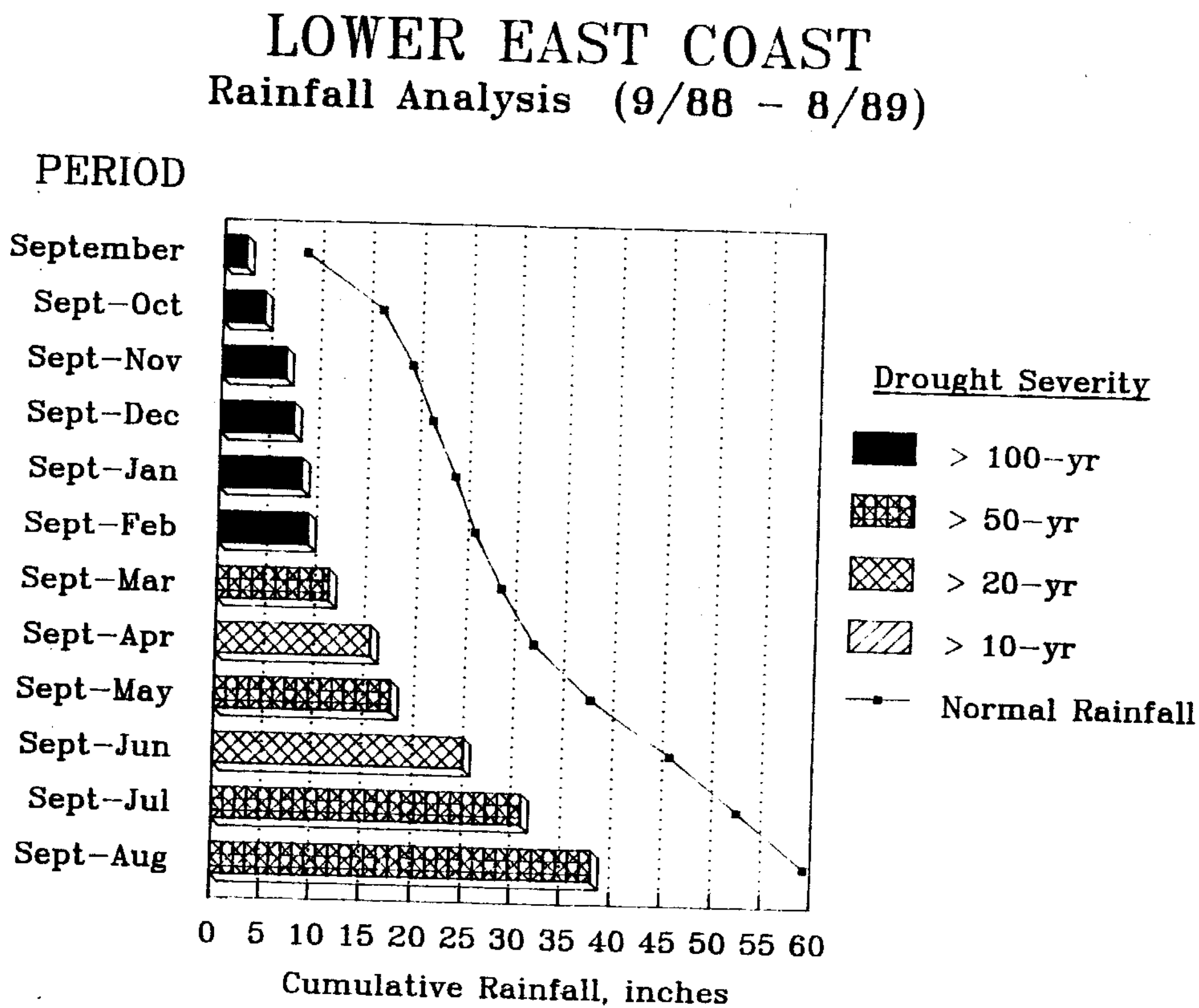


Figure 2.5 Lower East Coast Rainfall Analysis (9/88-8/89)

Lower Kissimmee Basin

This 674 square mile area extends from Lake Kissimmee south to Lake Okeechobee and is bounded by Martin County to the east. Runoff from this basin enters Lake Okeechobee via Structure 65E. Rainfall deficiency was greatest in September and October. The two-month total of 4 inches corresponded to a drought return period of greater than 50 years (Figure 2-6). The balance of the twelve-month period received 37 inches, just two inches below the normal rainfall amount. The resultant marginal drought (less than 10-year return period) was due to the low amount of rainfall received in September and October.

Lake Okeechobee

Lake Okeechobee is the largest fresh water lake lying wholly within the United States and is 730 square miles in size. Cumulative rainfall drought severity since September of last year was not as great for Lake Okeechobee as it was for the EAA and LEC (Figure 2-7). It fluctuated throughout the twelve months and through August 1989 it approximates a 1-in-10-year drought. Normal rainfall for the twelve-month period is 45 inches; 31 inches were recorded in 1988-1989. The 14-inch rainfall deficit over the lake corresponds to a volumetric deficit (due to rainfall) of approximately 550,000 acre-feet. Although the gauges used to estimate rainfall over Lake Okeechobee lie on the perimeter of the lake and do not include interior gauges (no long-term gauges exist on the lake), they are sufficient to capture some of the unique rainfall characteristics produced by the lake-atmosphere interaction. Refer to *Frequency Analysis of SFWMD Rainfall* (Sculley, 1986; SFWMD Technical Publication 86-6), for further information.

Water Conservation Area 3 (A&B)

Again, lack of rainfall in September and October produced greater than 100-year drought conditions in Water Conservation Area 3 (WCA-3). Moderate but below-normal rainfall from December through April reduced the severity of the cumulative rainfall deficit to between a 10- and 20-year drought (Figure 2-8). May and June rainfall was again below-normal, which returned WCA-3 to rainfall conditions exceeding the 50-year drought. July and August produced 7 and 8 inches, respectively, above the normal two-month amount of 13 inches. By the end of August, the cumulative twelve-month deficit was 12 inches: slightly greater than a 1-in-20-year drought for WCA-3.

Everglades National Park

Extremely low precipitation in Everglades National Park (ENP) from October through March contributed to 100-year drought rainfall conditions during the last half of the 1988-1989 dry season (Figure 2-9). Rainfall during this six-month period totalled 5 inches, over 8 inches below the normal amount. Although data at this time is provisional, it is indicated that rainfall during the 1989 wet season through August was normal, which alleviated cumulative rainfall to a 1-in-20 years' drought.

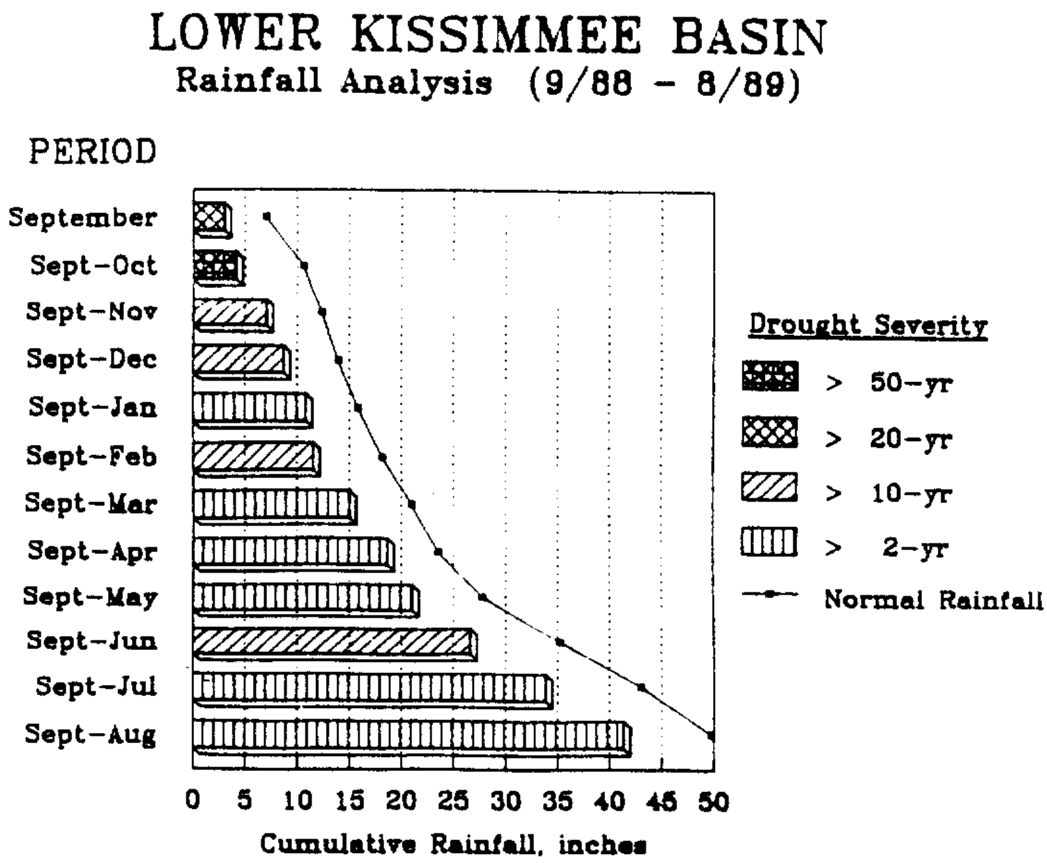


Figure 2-6 Lower Kissimmee Basin Rainfall Analysis (9/88-8/89)

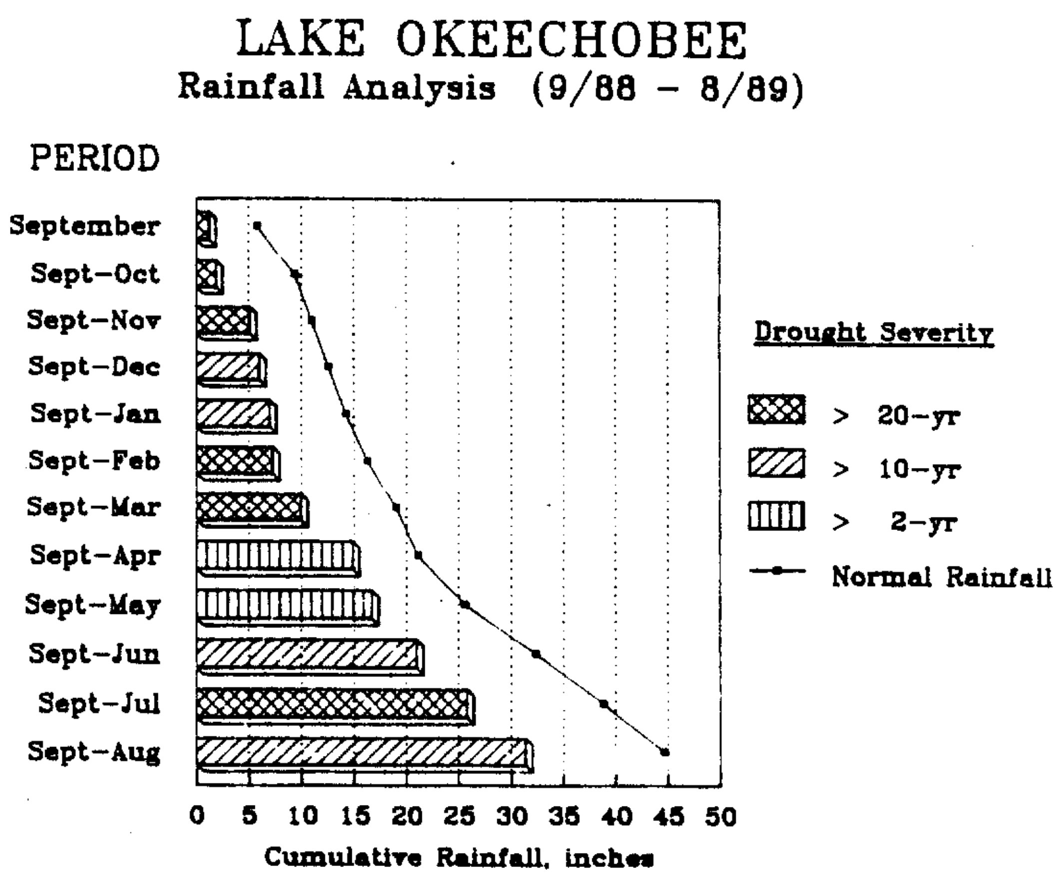


Figure 2-7 Lake Okeechobee Rainfall Analysis (8/88-8/89)

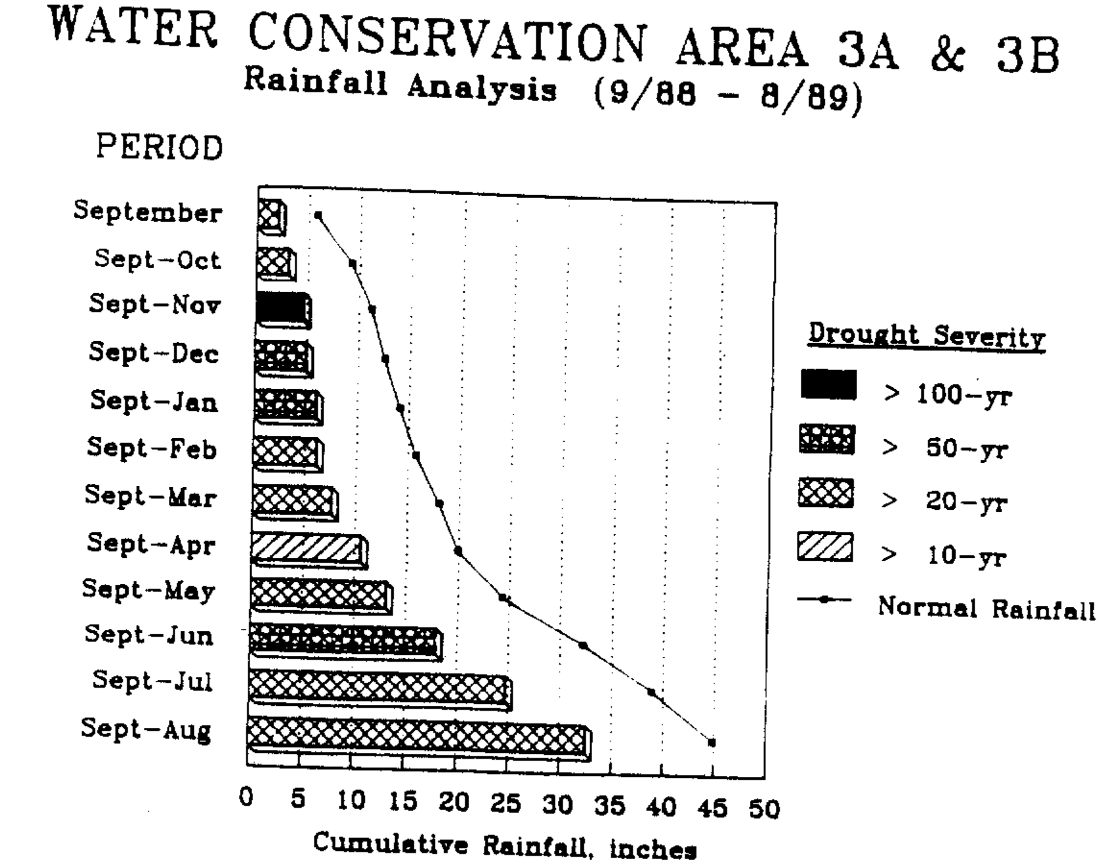
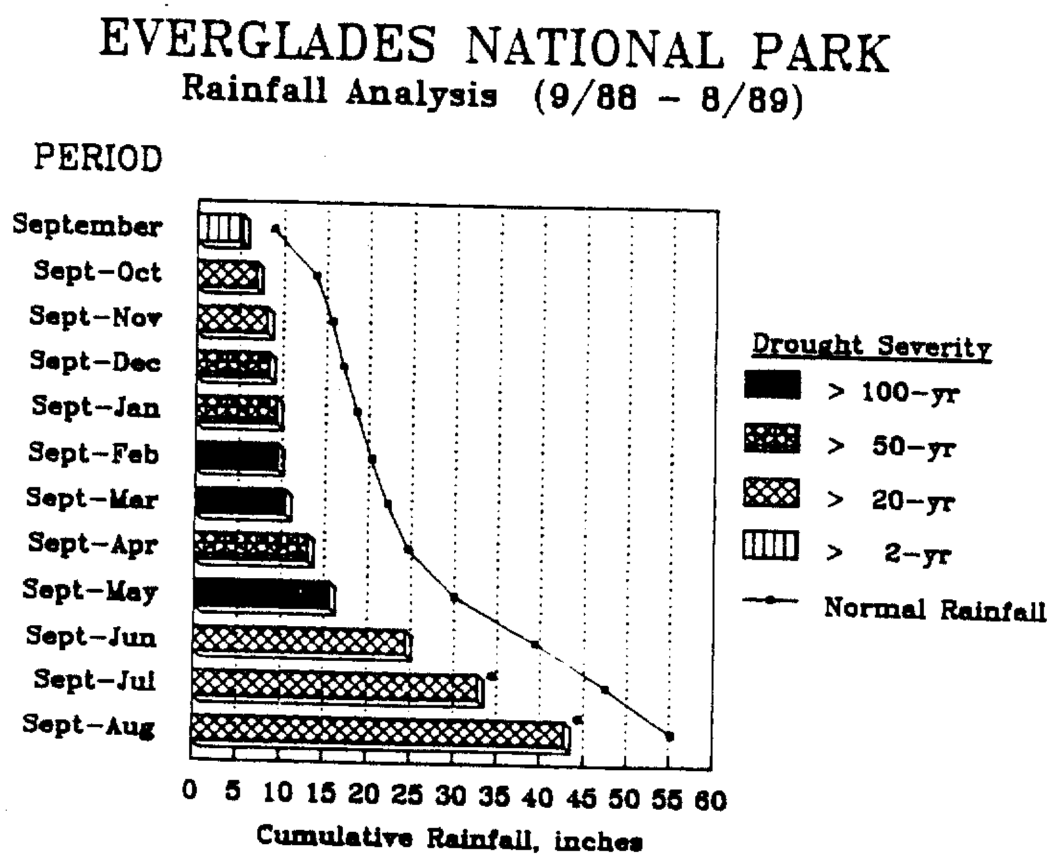


Figure 2-8 Water Conservation Area 3A & 3B Rainfall Analysis (9/88-8/89)



* provisional data

Figure 2-9 Everglades National Park Rainfall Analysis (9/88-8/89)

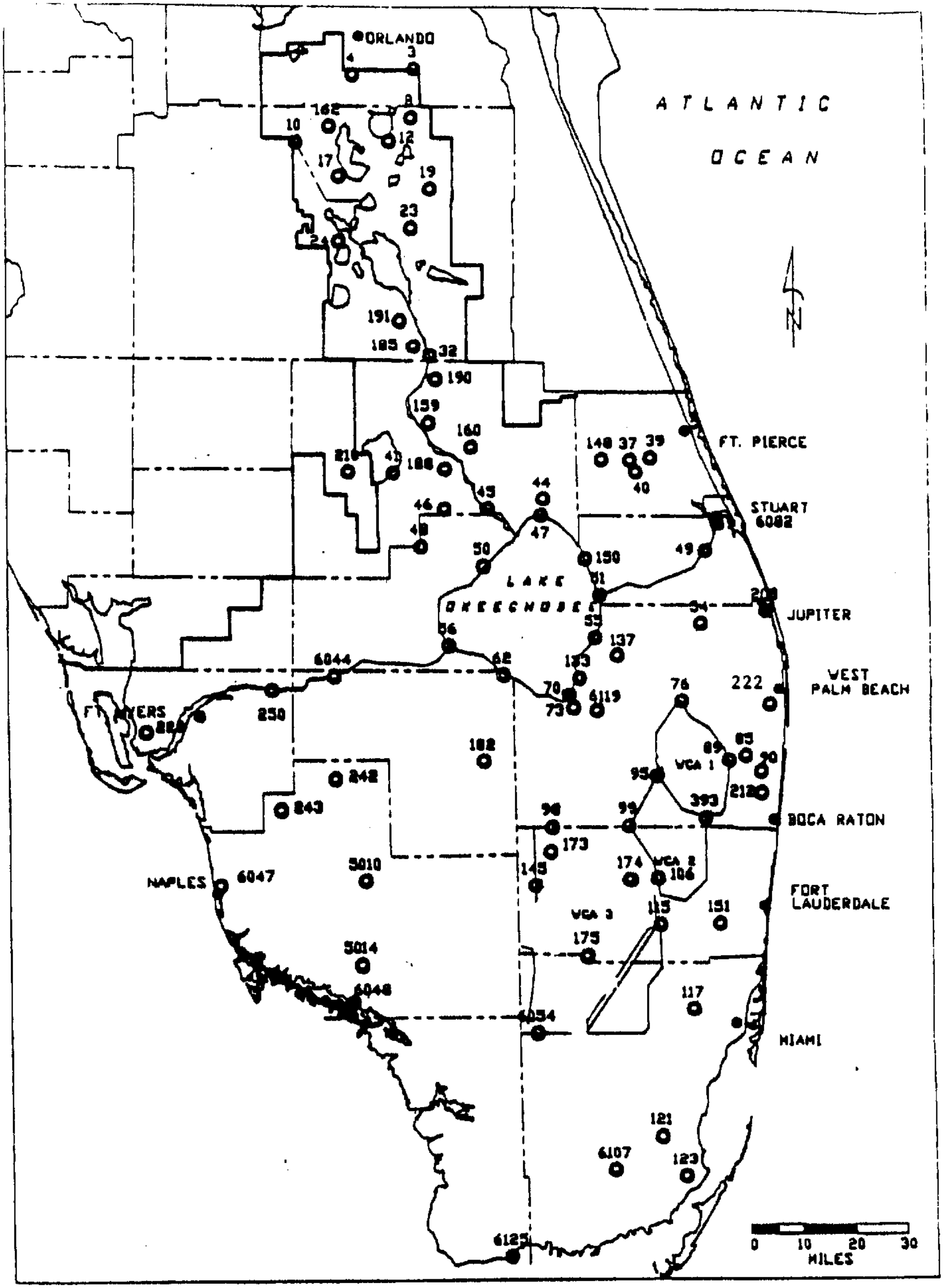


Figure 2-10 SFWMD Active Raingauges Used in the Analysis

TABLE 2-2. Active District Rainfall Gauges Used in Analysis

MRF	LOCATION	PERIOD
10	Reedy Creek	1968-89
106	WCA3A 3-36	1960-89
115	S-9	1960-89
117	Miami Field Station	1965-89
12	Brooks Property	1962-89
121	Homestead Field Station	1968-89
123	S-20	1968-89
133	East Shore	1970-89
137	Pahokee 1	1957-89
145	S-140	1971-89
148	Cow Creek Ranch	1970-89
151	Ft. Lauderdale Field Station	1971-89
159	Micco Bluff	1972-89
160	Bassinger	1972-89
162	Kissimmee Field Station	1972-89
17	Kirchoff Property	1969-89
173	WCA3A NW	1971-89
174	WCA3A NE	1971-89
175	WCA3A S	1971-89
182	Alico Property	1972-89
185	Maxcey North	1974-89
188	Lykes Bros. near Fort Bassinger	1974-89
19	Pine Island	1965-89
190	Maxcey South	1974-89
191	G.A.C. Property near S-65	1974-89
208	Jupiter Fire Station	1976-89
210	Lake Francis	1977-89
212	Military Trail and Lateral 38 (LWDD)	1974-89
222	West Palm Beach Field Station	1969-89
23	Chapman's Canoe Creek	1968-89
24	Snively's Ranch	1966-89
242	South Florida Field Laboratory USDA Immokalee	1959-89
243	Corkscrew Sanctuary	1968-89
250	Alva Farms/Yoder Bros.	1959-89
3	Beeline Highway	1965-89
32	S-65A	1965-89
39	Scotto Groves	1960-89
393	S-39.	1984-89
4	Taft	1968-89
40	Hayes Property	1971-89
41	S-68	1965-89
44	Okeechobee Field Station	1960-89
45	S-65E	1964-89

TABLE 2-2. Active District Rainfall Gauges Used in Analysis

MRF	LOCATION	PERIOD
47	S-193 (HGS-6) COE	1938-89
48	S-70	1965-89
50	Indian Prairie Canal at SR 78	1956-89
5010	Miles City Tower	1969-89
5014	Copeland Tower	1969-89
51	Port Mayaca Lock (COE)	1951-89
54	Pratt & Whitney	1957-89
56	HGS-1 (COE)	1951-89
6044	LaBelle	1929-89
6047	Naples	1942-89
6048	Everglades	1924-89
6054	Tamiami Canal at 40 Mile Bend	1941-89
6082	Stuart 1N	1935-89
6107	Royal Palm Ranger	1949-89
6119	Belle Glade Experiment Station	1924-89
6125	Flamingo	1962-89
62	HGS-2 (COE)	1951-89
70	HGS-4 (COE)	1951-89
73	South Bay	1959-89
76	S-5A	1956-89
8	Lake Myrtle	1953-89
85	Boynton Road and E2 (LWDD)	1928-89
90	Lake Worth Drainage District office (LWDD)	1955-89
95	S-6	1960-89
98	S-8	1962-89
99	S-7	1973-89

3. SURFACE WATER STORAGE IN MAJOR RESERVOIRS

This section presents an analysis of the storage in the South Florida Management District's major reservoirs including a comparison with average conditions and previous years. An analysis of the net losses represented by the change in storage is also illustrated in this section. Three major reservoir systems were analyzed, the Upper Kissimmee Lakes including Lake Istokpoga, Lake Okeechobee, and the Water Conservation Areas.

Total System Storage

The recent stages in the major reservoirs have been significantly below normal particularly in Lake Okeechobee and the Water Conservation Areas as shown in Figures 3-1, 3-2, 3-3, and 3-4. Lake Okeechobee is 2.5 feet below the historical average. Water Conservation Area 1 (WCA 1) was at record low stages during the months of January and February, 5 feet below the historical average. Water Conservation Area 2A (WCA 2A) has been 2 feet below average throughout this period, and Water Conservation Area 3A (WCA 3A) has had record low stages of with up to 3 feet below average since June 1989. The Upper Kissimmee Lakes have been at or near regulation throughout this drought period with the exception of Lake Kissimmee which has been 1.5 feet to 2 feet below regulation schedule.

The stage of 11.40 feet in Lake Okeechobee as of September 1, 1989, is the third lowest of the period of record. Only in 1956 when the stage was 10.31 feet and in 1981 when the stage was 11.07 feet, the Lake stage fell below this level. The low Lake stage in 1956 was partially due to a much lower Lake regulation schedule. The stage in WCA 3A was 8.33 feet on September 1 which is a a record low for this date. The storage in the surface water storage areas is very low compared to the last 20 years and lower than the low storage conditions of 1981 as can be seen in Figure 3-5. Even though Lake Okeechobee has presently more storage than in 1981, the Water Conservation Areas are significantly lower. This results in a record low total system storage as shown in Figure 3-6. The total available system storage as of September 1, 1989 is 1.70 million acre-feet, while for the same date in 1981 it was 2.15 million acre-feet.

Losses in Storage

The monthly change in storage is an indication of the severity of the drought. Figure 3-7 shows the monthly change in storage in the major surface water storage areas.

The Upper Kissimmee Chain of Lakes gained storage during the wet season months and lost storage in the dry season months although these gains and losses were slightly below normal.

Lake Okeechobee experienced a steady decline since late September 1988 until July 1989 with a light recovery in late July and August as shown in Figure 3-7. The lake experienced major losses in October and December 1988, and February, May and June 1989. During the wet season months of June, July, and August in which the lake normally gains storage, it experienced a 200,000 acre-foot loss during 1989.

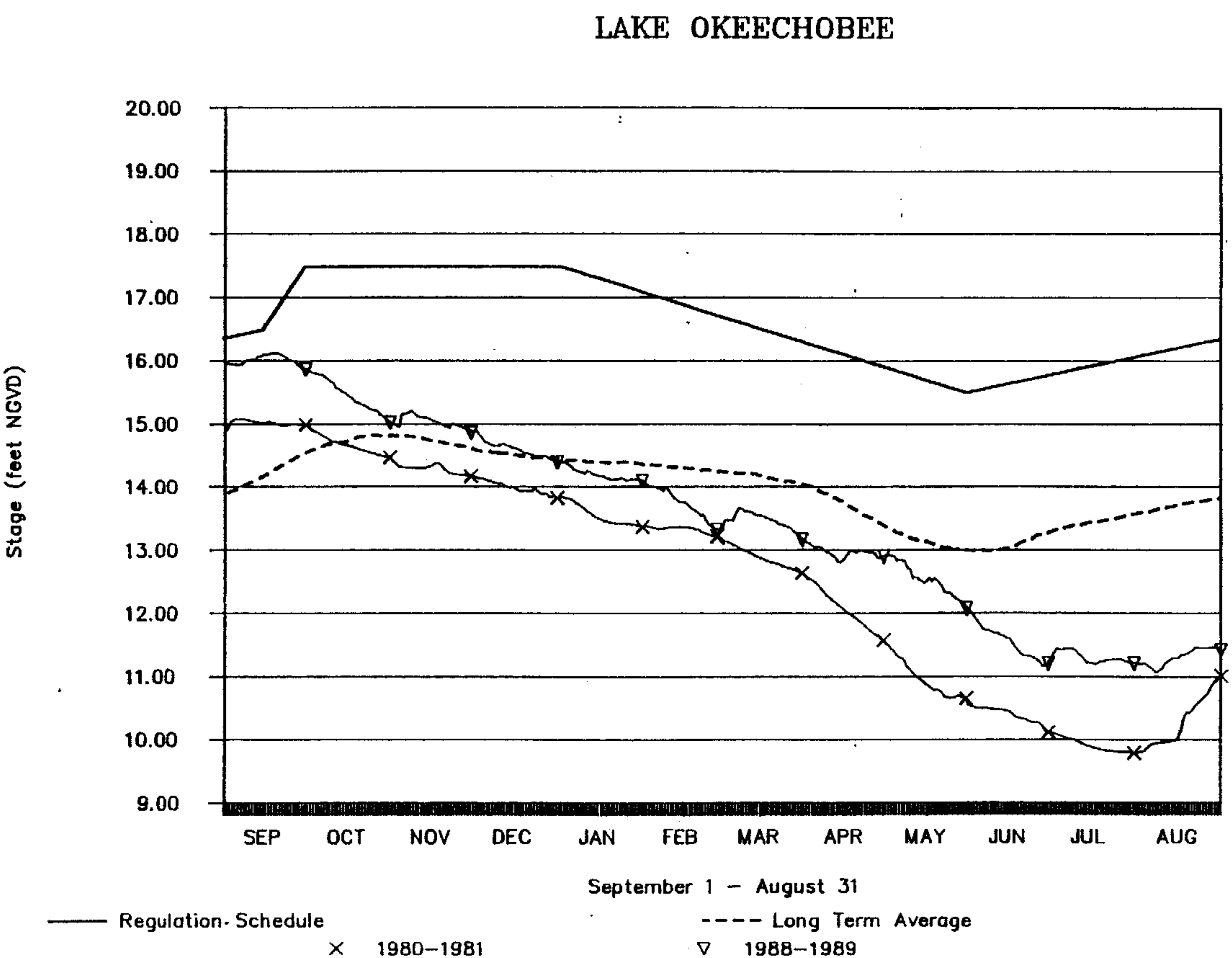


Figure 3-1 Lake Okeechobee

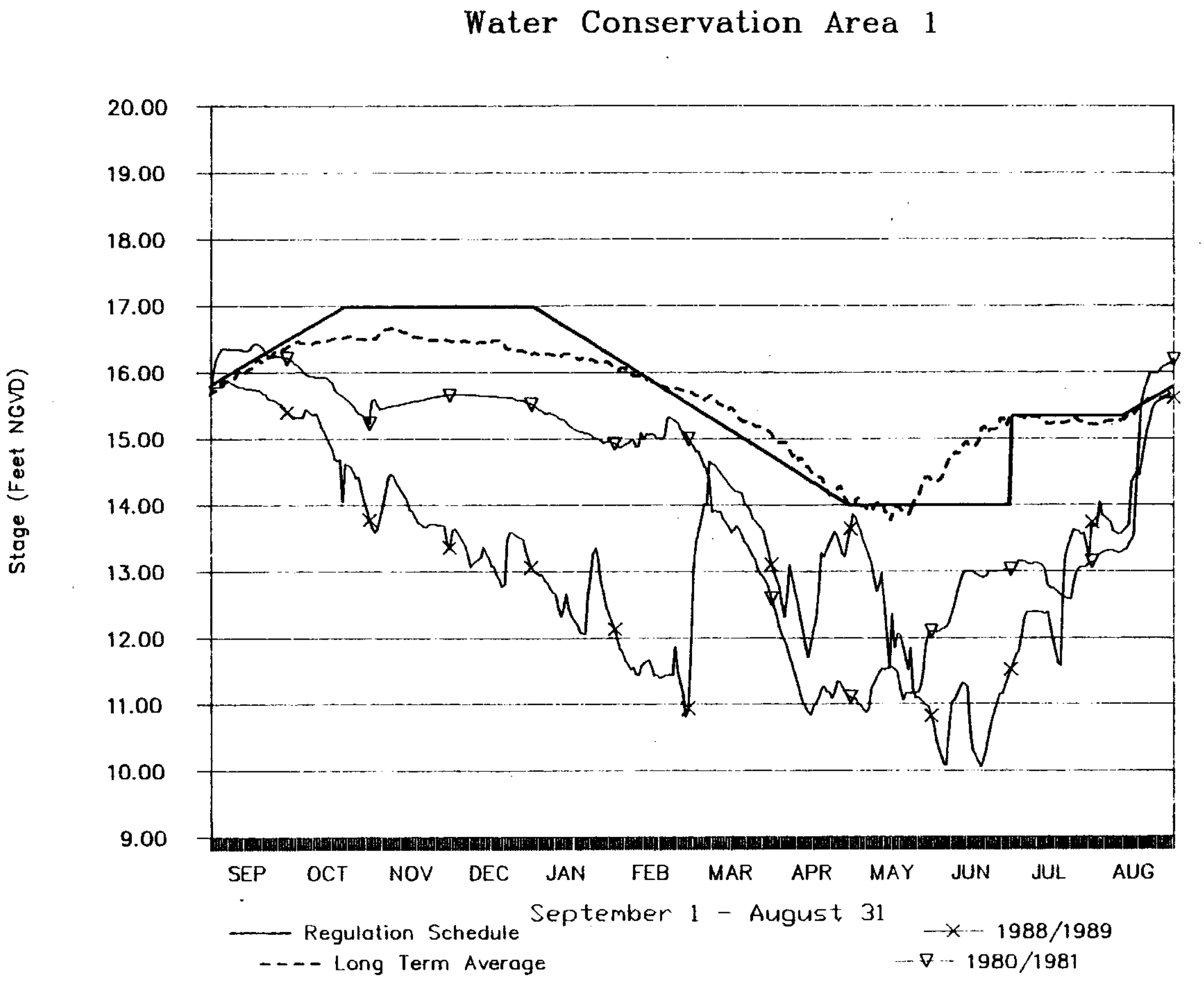
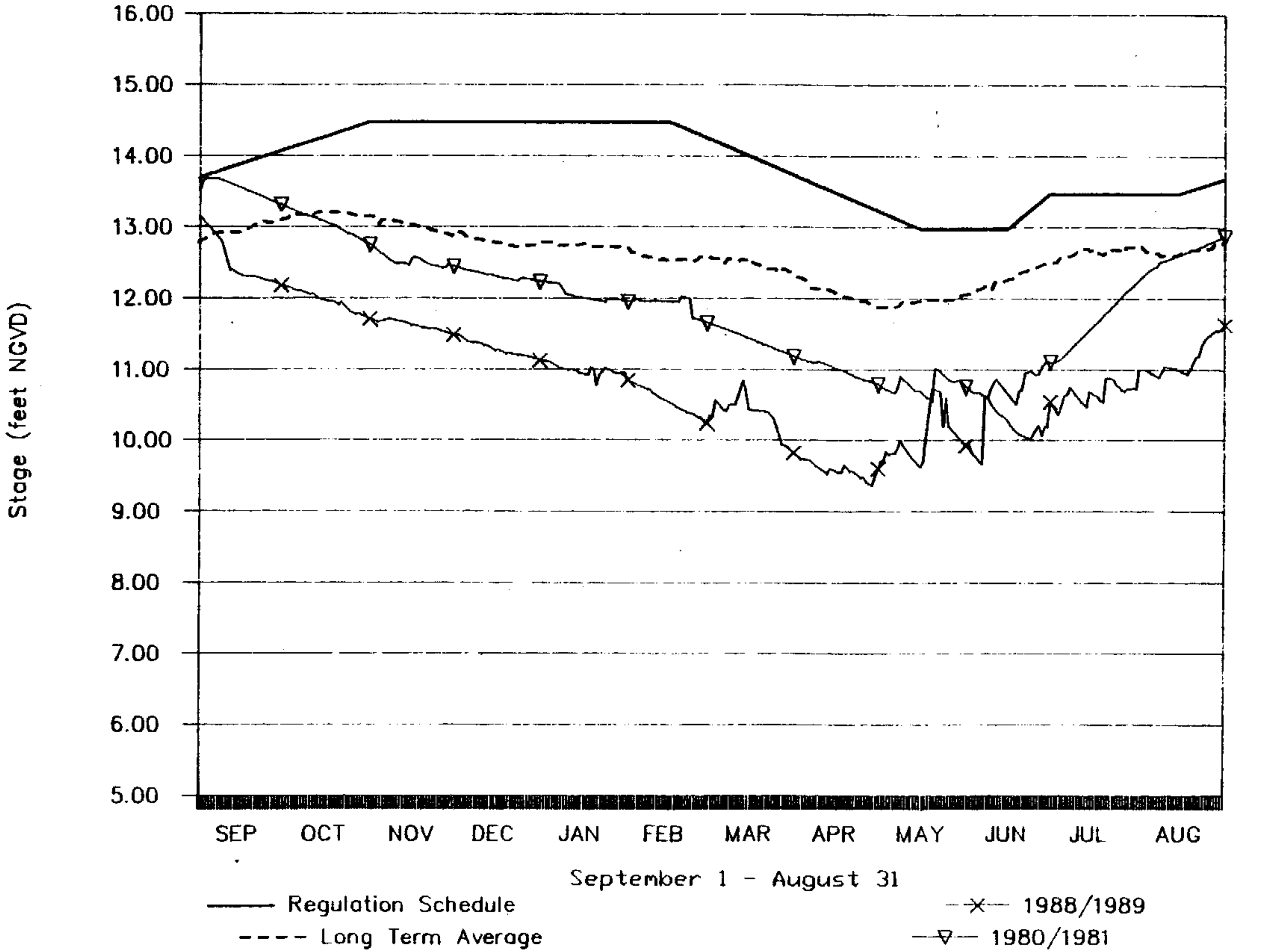


Figure 3 2 Water Conservation Area 1

Water Conservation Area 2A



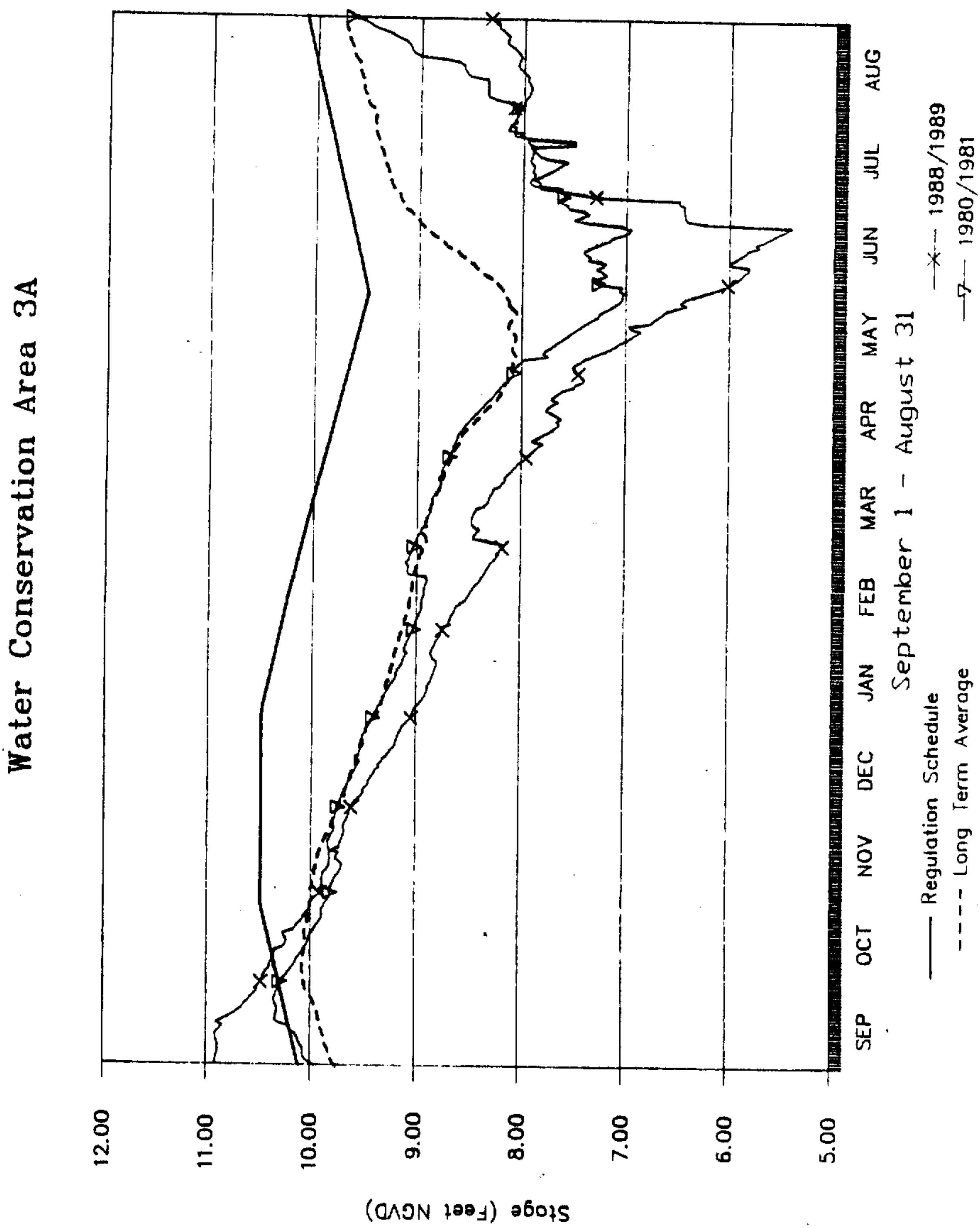


Figure 3 4 Water Conservation Area 3A

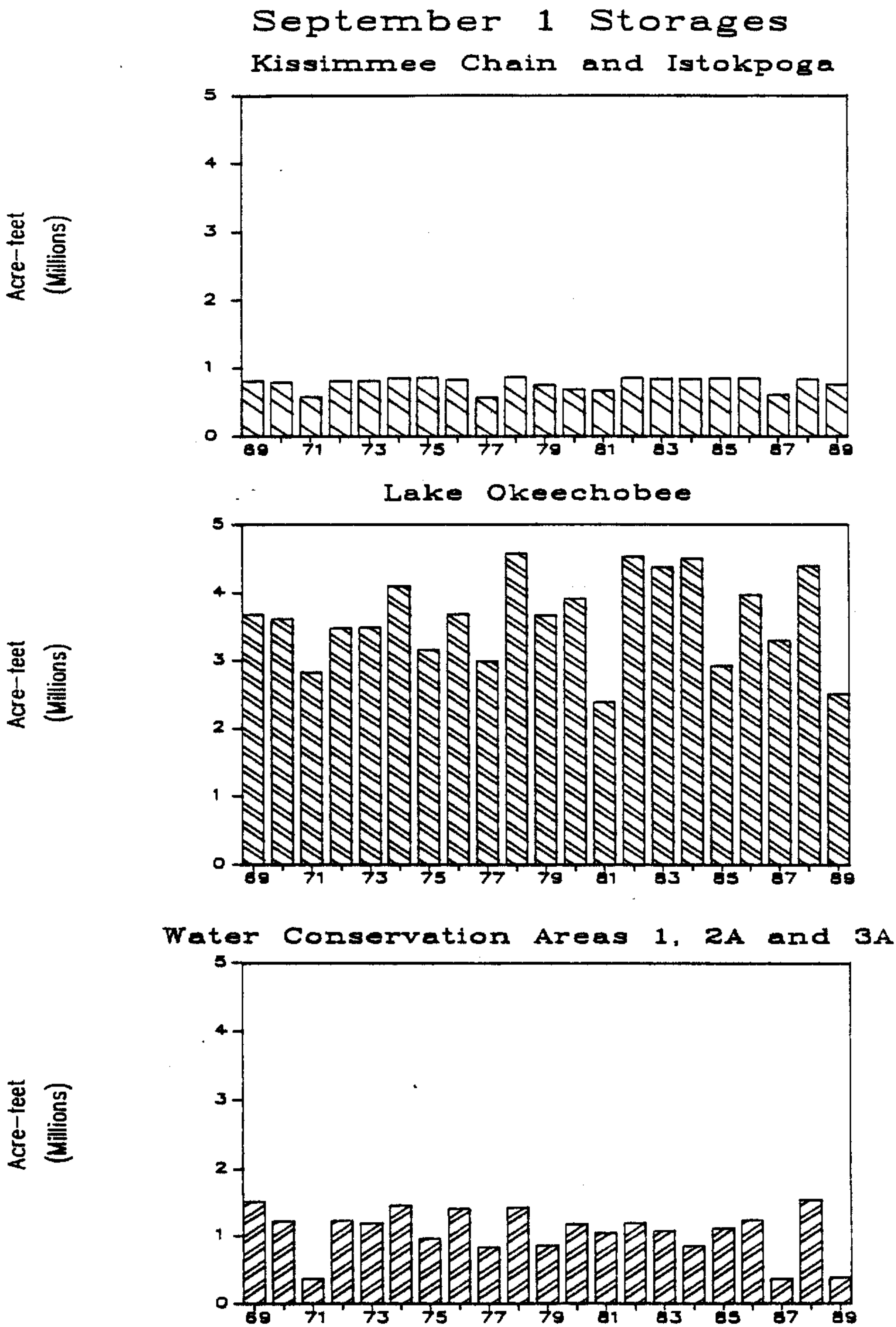


Figure 3-5 September 1 Storages

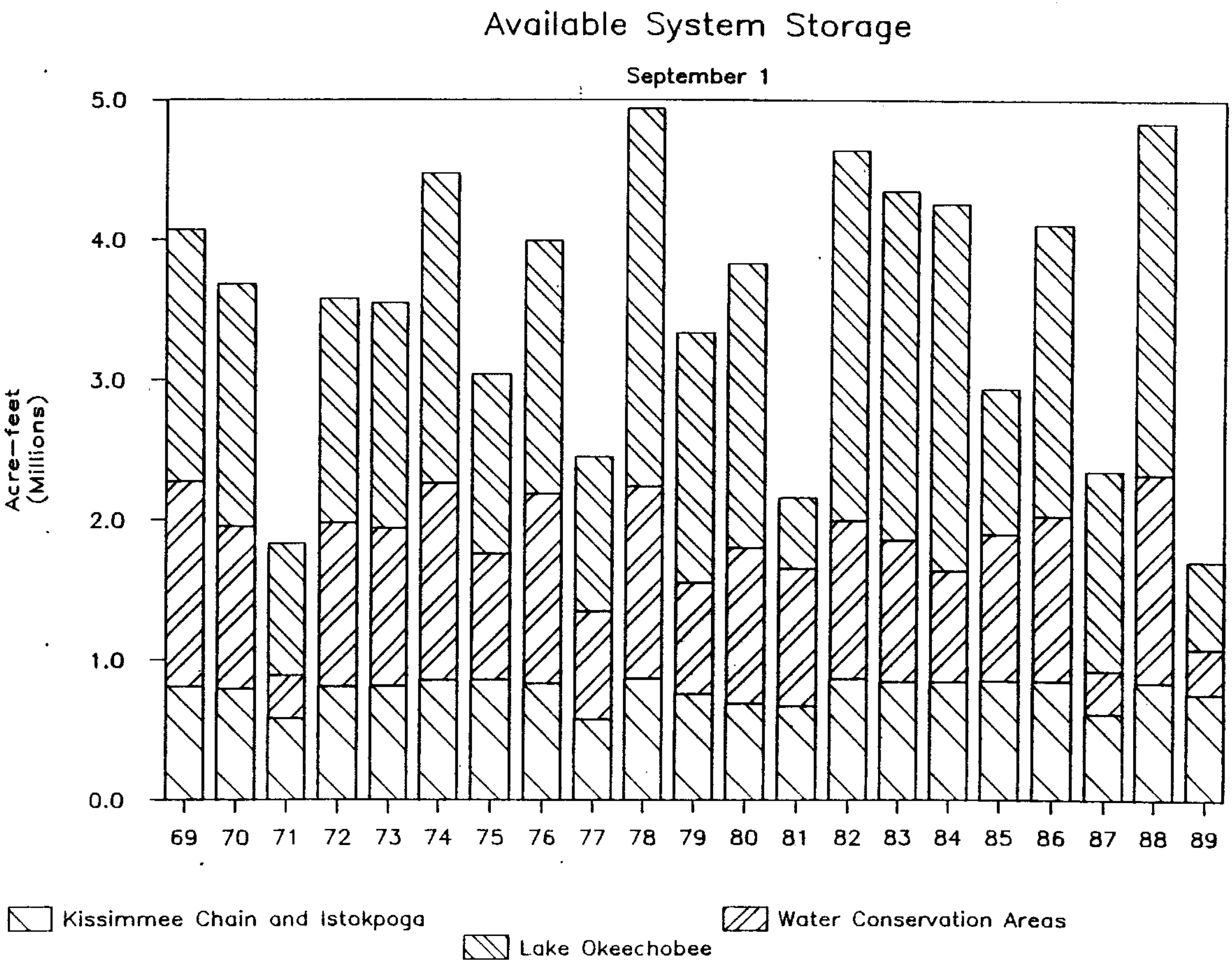


Figure 3 6 Available System Storage September 1

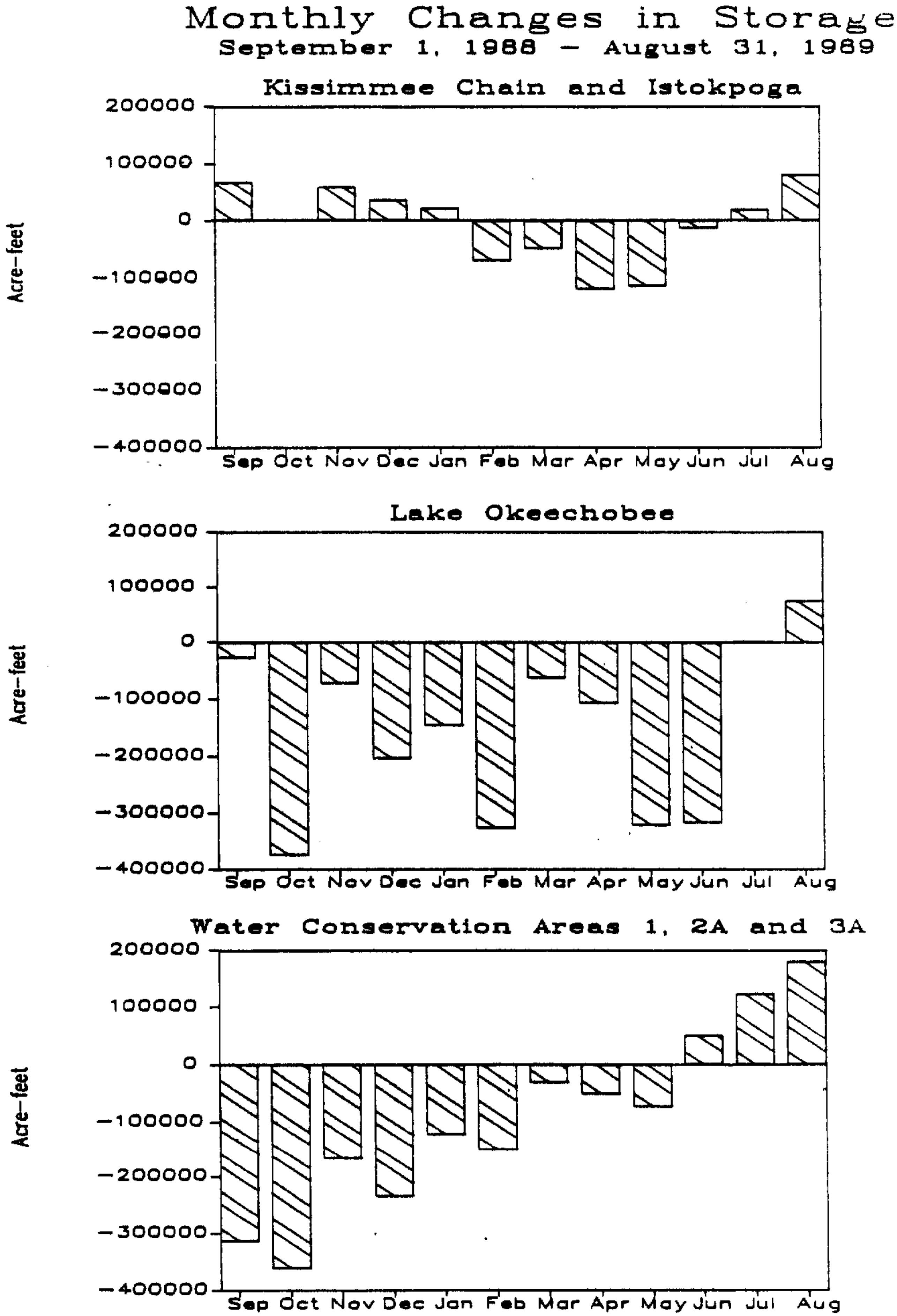


Figure 3-7 Monthly Changes in Storage Sept. 1, 1988-Aug. 31, 1989

The Water Conservation Area system experienced significant losses in storage since September 1988 until June 1989, although slight gains in storage has occurred in June, July, and August as shown in Figure 3-7. Those gains were primarily in WCA 1 and WCA 2A. WCA 3A still remains well below the historical average with significantly below normal gains in storage. Figure 3-8 presents a comparison of the changes in storage for the study period in the major surface water supply areas. It shows that Lake Okeechobee and the Water Conservation Areas experienced record losses.

The monthly change in storage in the total surface water supply system is illustrated in Figure 3-9. As can be seen in this figure, the total water supply system lost significant amount of storage during the dry season months and the wet season months of September, October, and June. Although the System gained a small amount of storage in July and August, the gains were smaller than the historical average for those months. In September 1988, the Surface Water Supply System lost 272,000 acre-feet compared to the average historical gain of 613,000 for that month. This represents a difference of 875,000 acre-feet. Likewise, in October 1988 the system lost 735,000 acre-feet compared to the historical average of a loss of 20,000 acre-feet, representing a difference of 710,000 acre-feet. Therefore, in the first two months of the drought, the System lost 1.85 million acre-feet more than the average. Large losses were also experienced in February, May, and June 1989.

The total system storage dropped from 6.79 million acre-feet on September 1, 1988 to 3.65 million acre-feet on August 31, 1989. Figure 3-10 shows that for the last 20 years, the System loss of 3.13 million acre-feet from September 1988 through August 1989 has been the largest, more than one million acre-feet larger than any previous year. This indicates the severity of this drought and the impact on the water storage areas. The main difference between this drought, and the 1970-71 and 1980-81 droughts, is that in this drought both the Everglades Agricultural Area and the Lower East Coast suffered severe rainfall deficiencies, while in 1970-71 the drought was primarily in the coastal areas, and in 1980-81 the drought was primarily in the interior while the Water Conservation Areas and the coastal areas experienced near normal rainfall.

Change in Storage Sept. 1 – Aug 31

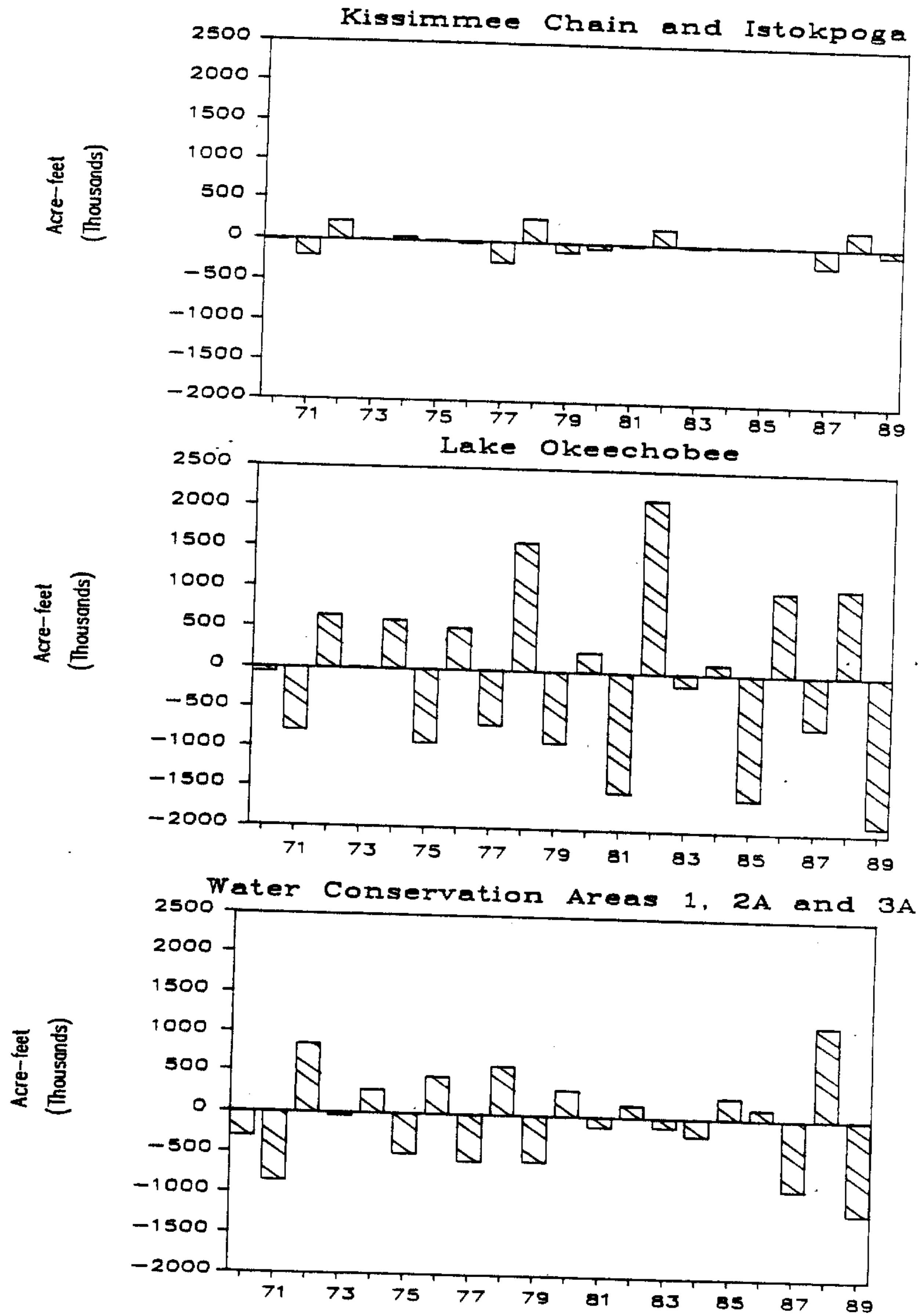


Figure 3-8 Change in Storage Sept. 1-Aug. 31

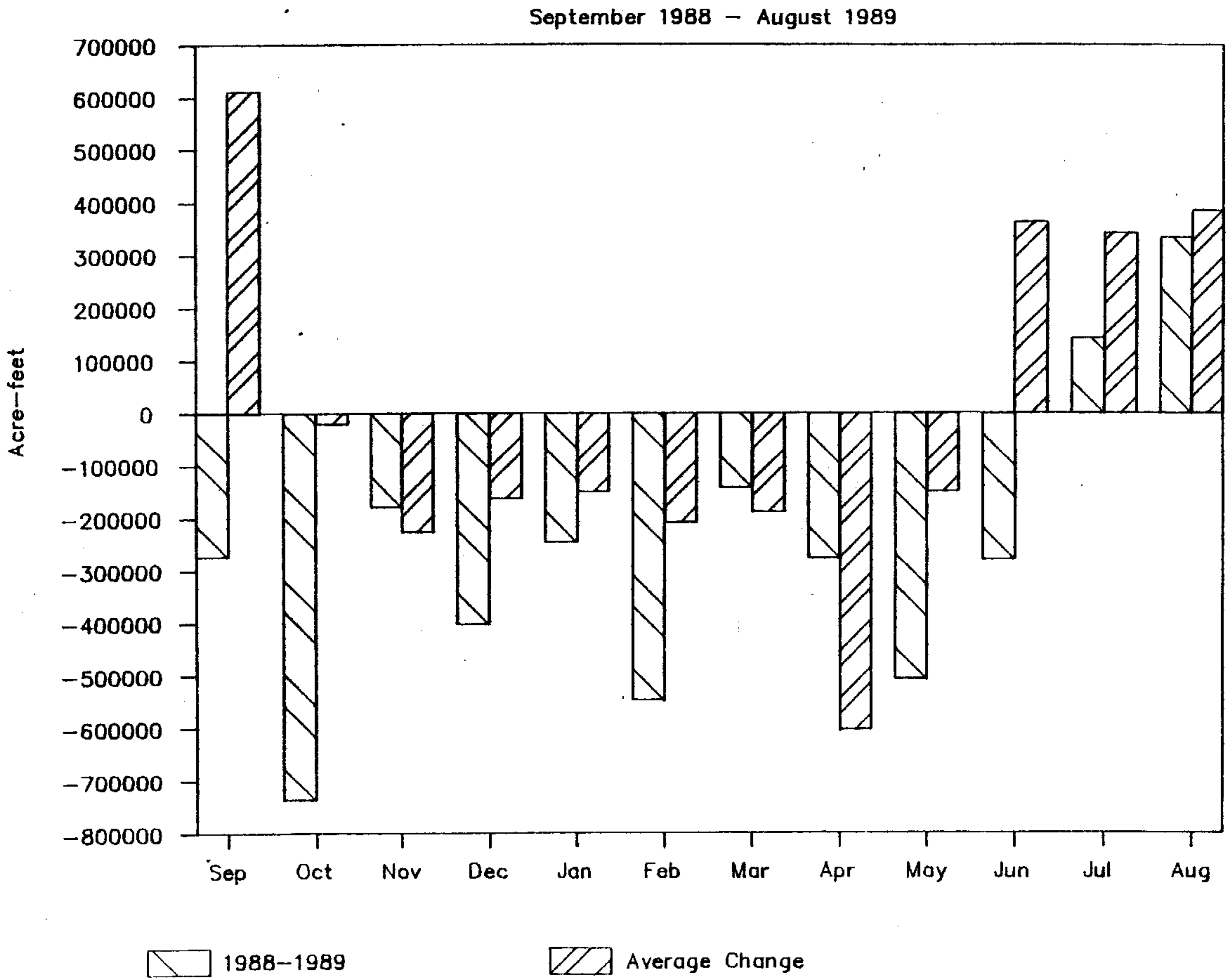


Figure 3-9 Total System Monthly Change in Storage Sept. 1988-Aug. 1989

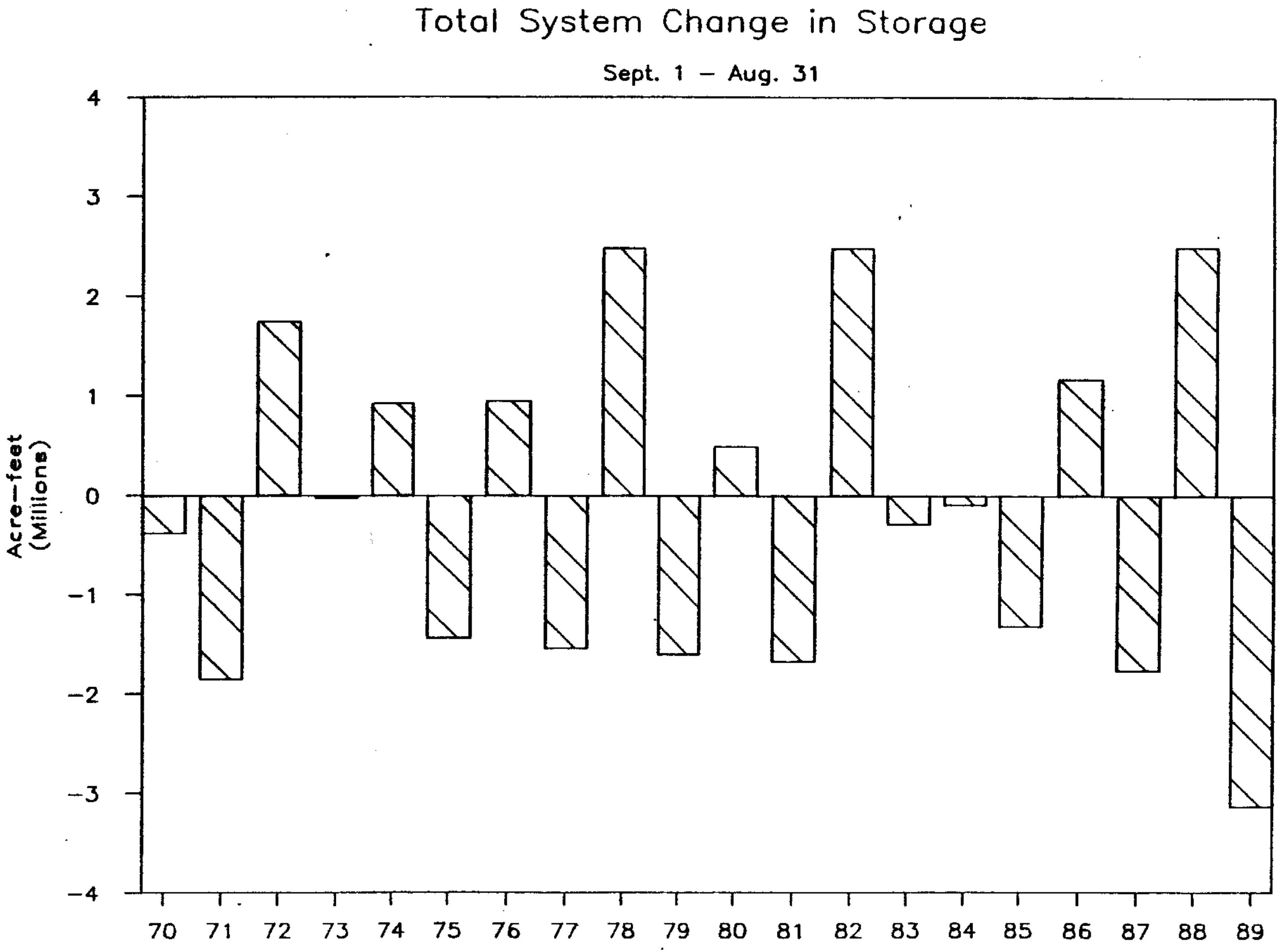


Figure 3-10 Total System Change in Storage Sept 1 Aug 31

4. WATER BUDGET ANALYSIS

A water budget normally is used to analyze the hydrologic behavior of a surface water reservoir. This type of approach summarizes all the inflows and outflows including rainfall (RF) and evapotranspiration (ET) from the Lake and each of the Water Conservation Areas to explain the net loss in storage for each storage area. In this section this technique will be used to illustrate the effect of the reduction in rainfall during the period of September 1988 through August 1989 in Lake Okeechobee and the Water Conservation Areas. A comparison with average conditions is also presented in this section.

Lake Okeechobee

A. Average Conditions

Lake Okeechobee is an enormous body of water covering a surface area of approximately 450,000 acres. A small decrease in RF or increase in ET can cause a tremendous loss of storage. Annual average ET as reported by the U. S. Corps of Engineers is 56 inches and exceeds the annual average rainfall of 44 inches by about a foot over the surface area of the Lake. This one foot loss in stage is equivalent to a loss in storage of about 450,000 acre-feet (AF) of water. In addition to the direct net loss in storage, the Lake also supplies water for agricultural and municipal use to regions surrounding the Lake which are directly dependent on the lake for water supply. These regions are broken down into subservice areas that are defined by basins or a number of basins dependent on the Lake for water supply. The principal subservice areas dependent on the lake for water are illustrated in Figure 4-1. The Everglades Agricultural Area, the Caloosahatchee River basin, and the St. Lucie Canal basin are the three largest users of the Lake water. Other subservice areas that also use significant amounts of water are coastal north Palm Beach County which includes the city of West Palm Beach and the C-51 canal and the northern rim of the Lake which uses some water particularly during high stages. During extended dry periods, the Lake is also a backup water supply for the three Lower East Coast Service Areas illustrated in Figure 4-1. Lower East Coast Service Area 1 is southern Palm Beach County, Service Area 2 is Broward County, and Service Area 3 is Dade County. During normal years minimal water is required from the Lake for water supply to these coastal service areas as the Water Conservation Area storage is sufficient for their needs. Normal water supply deliveries from the Lake to its service areas are 600,000 AF.

The loss in storage due to water use and ET is usually replenished by the large surface water inflow that enters the Lake from its large drainage basin. The tributary area to the north of the Lake, which includes Fisheating Creek, Lake Istokpoga and its tributaries, the Kissimme River basin, Taylor Creek and Nubbin Slough is over 3 million acres (shaded area in Figure 4-1). Historical average annual inflow from these basins is 1.71 million AF. The inflow from the Kissimme River Basin alone accounts for 974,000 AF. The summary of average annual inflows appears in Table 4-1. Normally the Lake experiences an annual net surplus in storage of 660,000 AF of water even after supplying the large consumptive needs of south Florida. This surplus usually occurs during the wet season which extends from June through mid-October.

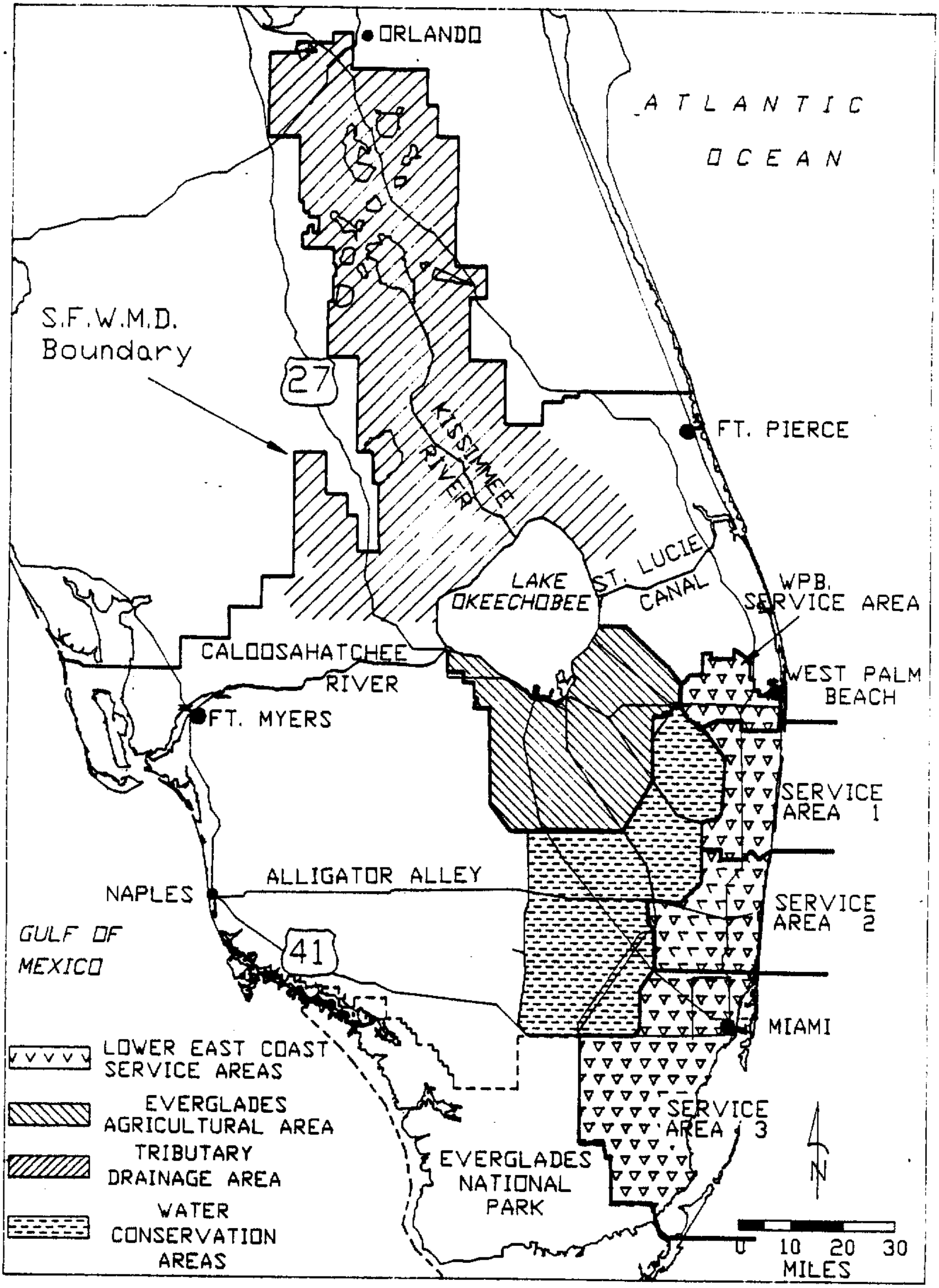


Figure 4-1 Major Tributary & Service Areas of Lake Okeechobee

TABLE 4-1
Summary of Average Inflow to the Lake

Inflow Point	Volume (AF)
S-4	27,347
Indian Prairie	339,163
S-65E	974,018
Fisheating Creek	162,315
Others	209,743
TOTAL	1,712,586

B. 1988-1989 Drought Conditions

The different components of the water budget for the Lake during this drought period appear in Figure 4-2. The dominant effect of ET should be noted. The 12 month period beginning September 1988 and extending through August 1989 represented a drought event with a return period of about once in 50 years, as discussed in Section 2.

In September 1988 the South Florida Water Management District experienced one of its driest Septembers on record. The RF for this month was 5 inches (187,000 AF) below normal and was nearly 4 inches (150,000 AF) less than the ET that occurred from the surface of the Lake during this month. October 1988 was just as dry so that the dry season, which normally extends from November through May, begin in September. Figure 4-3 illustrates a monthly comparison between the 1988 RF and the average rainfall. During May, June, and July of 1989 rainfall was again significantly below normal. During the 12 month period, the Lake received only 32 inches (1,120,000AF) or 12 inches (450,000 AF) less than normal. The loss due to ET was at least 2 inches (75,000 AF) greater than normal due to the hot dry conditions that existed during this period increasing the effects of the rainfall deficit. Figure 4-4 depicts the monthly difference between 1988-1989 RF and ET. The large deficits in September, October, January, February, and May should especially be noted. Figure 4-5 illustrates the total inflow versus the total outflow including the effects of rainfall and evapotranspiration. Although September experienced a large deficit between RF and ET ,it only had a slight deficit in storage due to the runoff generated by early summer rainfall. All the other months from October 1988 through June 1989 experienced significant deficits in storage. July and August 1989 experienced a slight surplus of inflow. Total surface inflows into Lake Okeechobee for this period were 840,000 AF. This is about 50% of the normal runoff to be expected to enter the Lake. Figure 4-2 graphically depicts the breakdown of inflow to the Lake on a monthly basis.

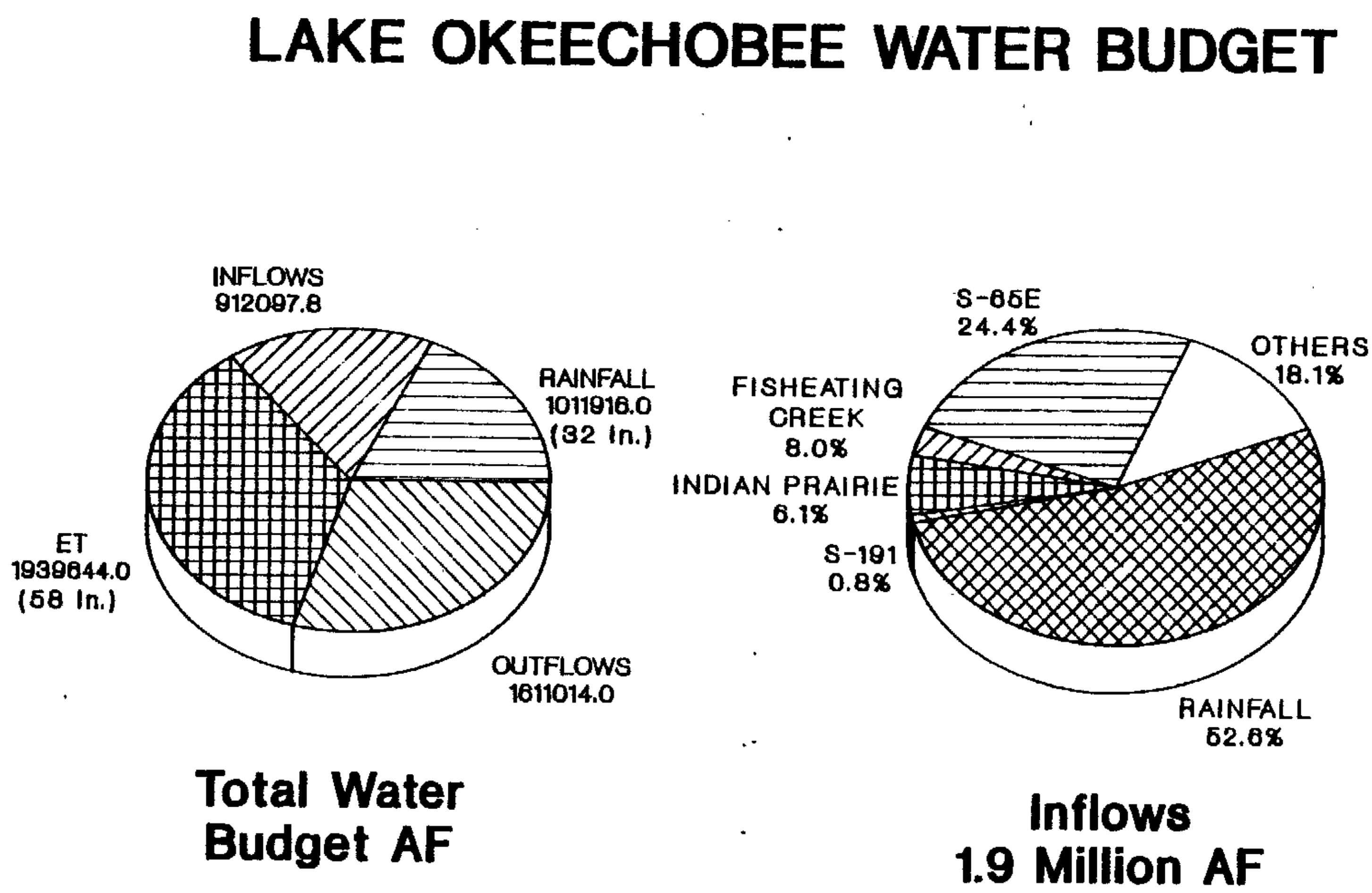


Figure 4-2 Lake Okeechobee Water Budget

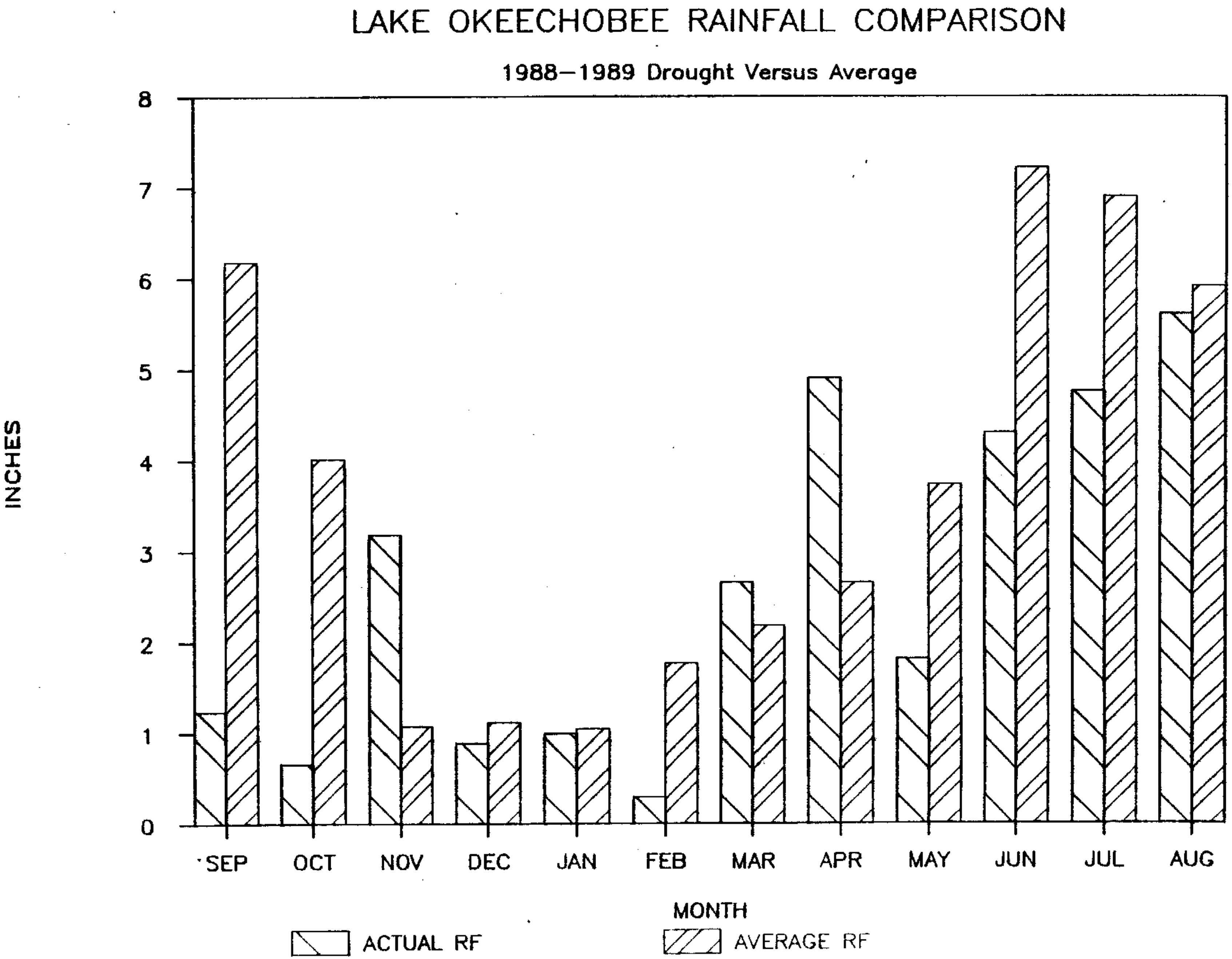


Figure 4-3 Lake Okeechobee Rainfall Comparison 1988 1989 Drought versus Average

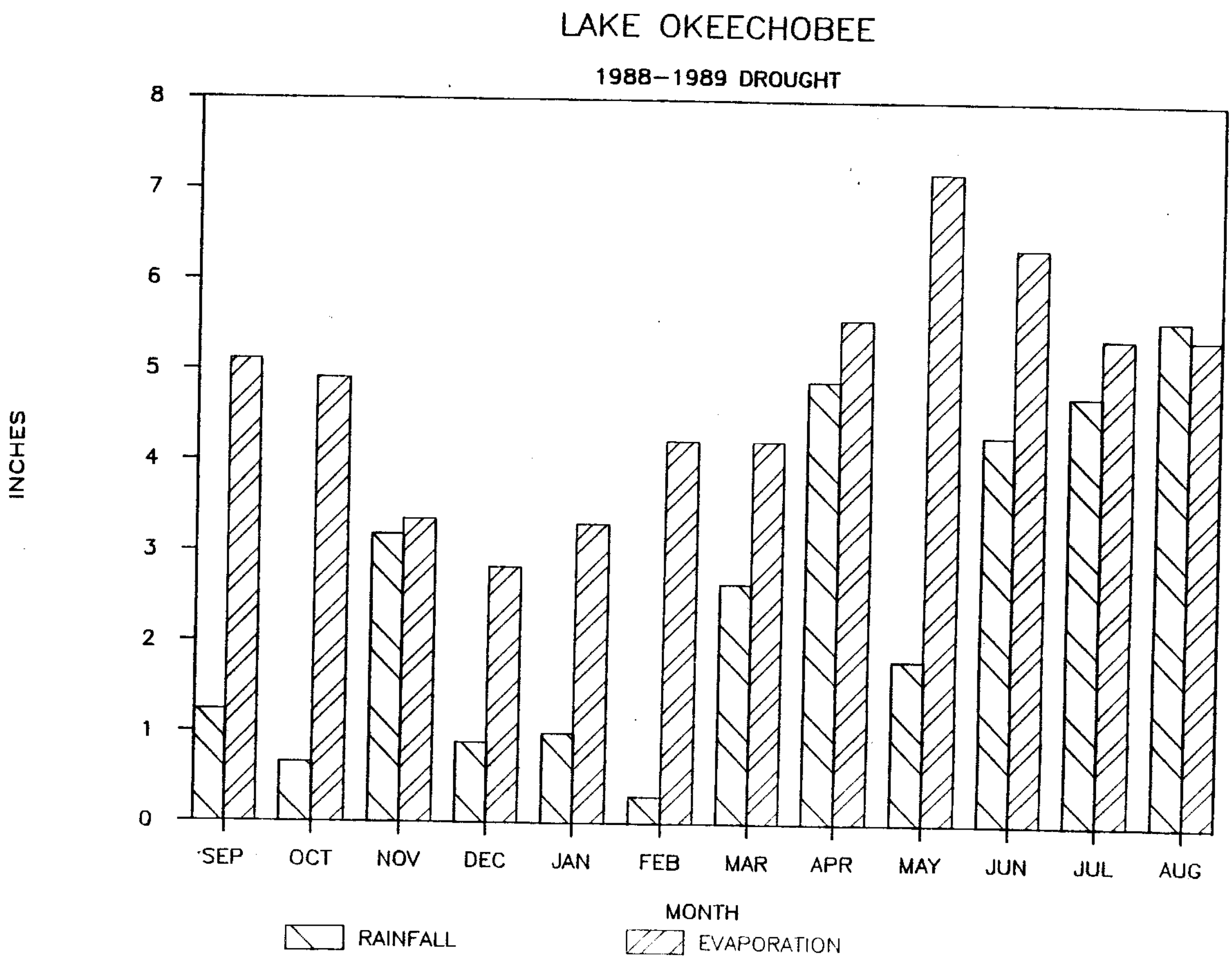


Figure 4-4 Lake Okeechobee 1988 1989 Drought

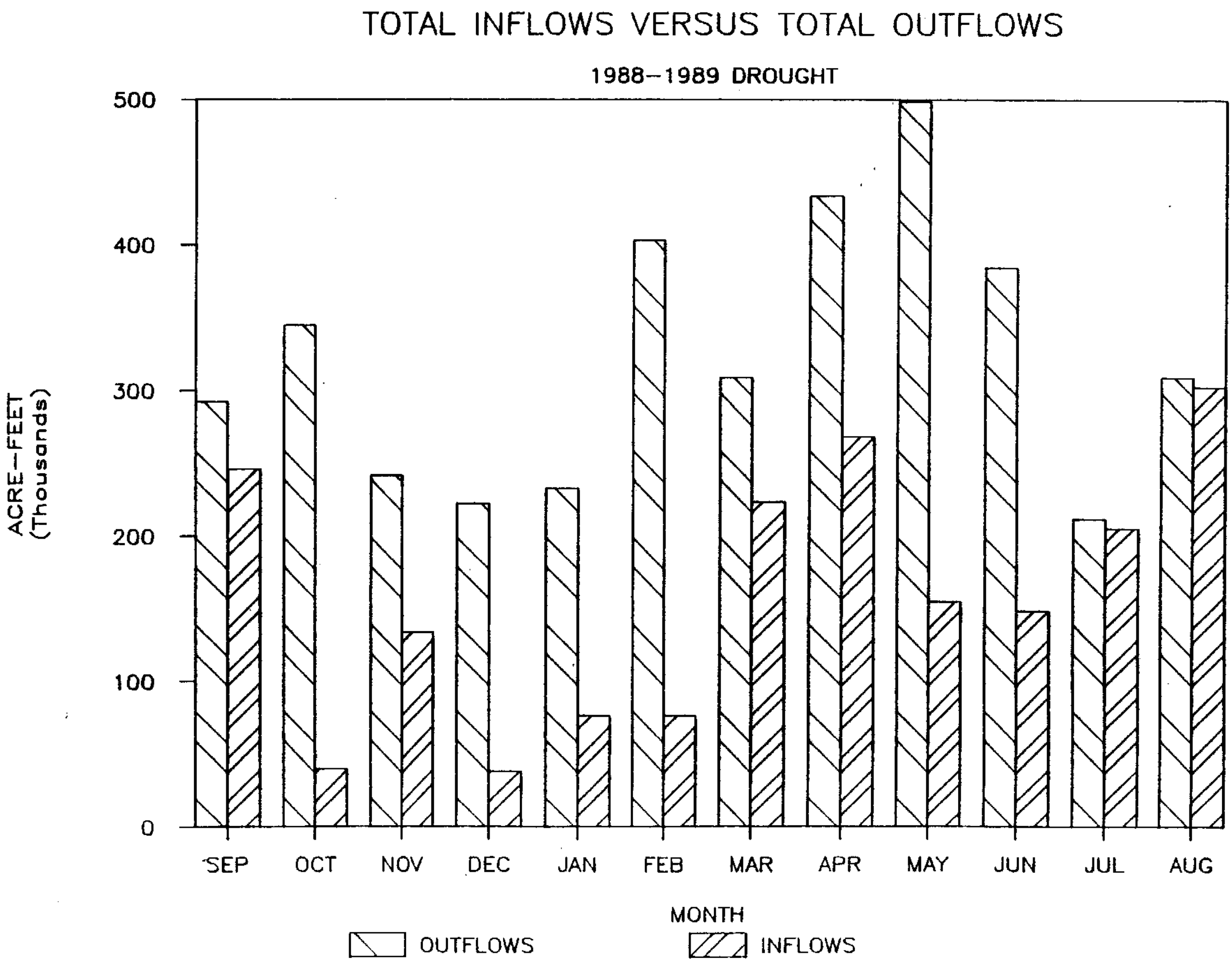


Figure 4-5 Total Inflows versus Total Outflows 1988 1989 Drought

The water use requirements are greatly magnified during periods of below normal rainfall. During a normal year water use delivered from the lake is approximately 600,000 AF, while during the 12 month period of this analysis, the water use deliveries from the Lake were 1,612,000 AF. Table 4-2 compares the 1988-1989 water budget components to those of a normal year. The positive net gain in storage during a normal year explains the need for occasional regulatory releases from the Lake. It is interesting to note that even though the rate of ET is higher during the drought, the volume of ET is less, due to the smaller surface area of the Lake at lower stages. Figure 4-6 illustrates the monthly distribution of inflows to the lake

TABLE 4-2
Comparison of Flows for 88-89 Versus a Normal Year
Lake Okeechobee (AF)

	Normal Year	1988-89	Net Effect
RF	1,640,000	999,000	-641,000
Surface Inflow	1,710,000	840,000	-870,000
ET	2,090,000	1,965,600	124,000
Surface Outflow	600,000	1,612,000	-1,012,000
TOTAL	660,000	-1,738,600	-2,398,600

C. Water Conservation Areas

The water budget for the Water Conservation Areas appears in Table 4-3.

TABLE 4-3
1988-1989 Water Conservation Area Water Budgets (AF)

	RF	ET	Seepage	Inflow	Outflow	Net Change
WCA 1	35,600	99,000	43,000	228,500	224,600	-102,500
WCA 2A	50,900	144,700	92,500	59,000	131,400	-258,700
WCA 3A	660,000	1,535,000	273,700	634,000	568,800	-1,083,500
TOTAL	746,500	1,778,700	408,200	921,500	924,800	-1,444,700

Water Conservation Area 3A experienced a tremendous loss of storage due to ET. The volume lost to ET alone for the study period is greater than the storage in the Water Conservation Area at the beginning of the period when the water level was at 10.92 feet (NGVD) and the storage was 1,193,000 AF. Evapotranspiration and seepage accounted for 75% of the outflow from WCA 3A. Surface outflows from

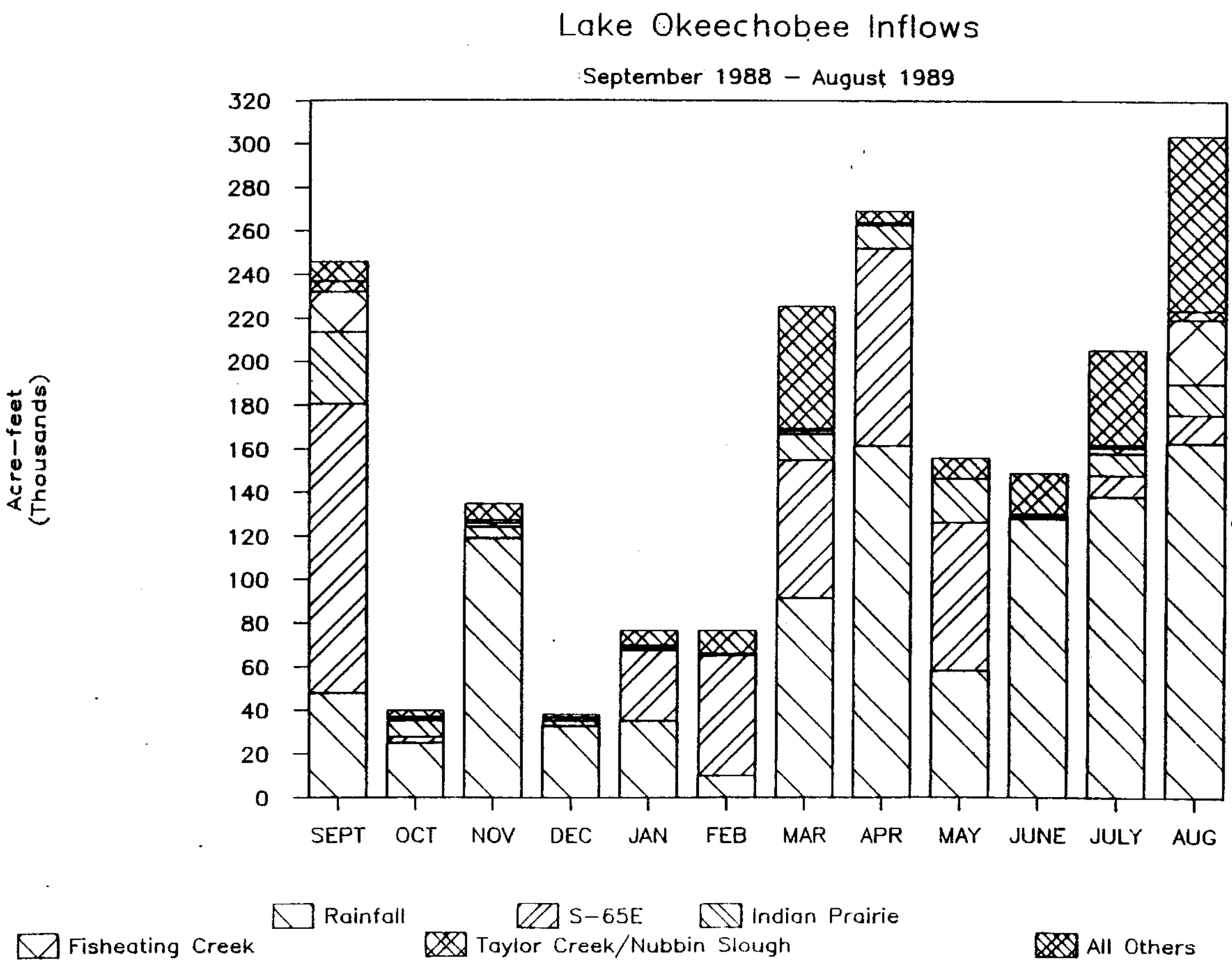


Figure 4-6 Lake Okeechobee Inflows Sept. 1988 Aug. 1989

WCA 3A were slightly less than surface inflows. ET and seepage were the primary factor.

Water Conservation Area 1 and 2A cover a significantly smaller surface area. The net difference between RF, surface inflows and outflows is minimal. The majority of the change in storage to WCA 2A was due to ET and seepage. In WCA 1, the volume of rainfall was less than the estimated seepage out of the area. ET losses were still a major component of the overall budget. Figure 4-7 illustrates the components of the budget for the Water Conservation Areas. Figures 4-8, 4-9, and 4-10 show the monthly inflows to Water Conservation Areas 1, 2A, and 3A, respectively. During June and July 1989 the Water Conservation Areas began to get significant runoff from the EAA. Prior to that period, many of the surface inflows were delivered from Lake Okeechobee.

A detailed analysis of the outflow component of the water budget indicating the water supply distribution is presented in Section 5.

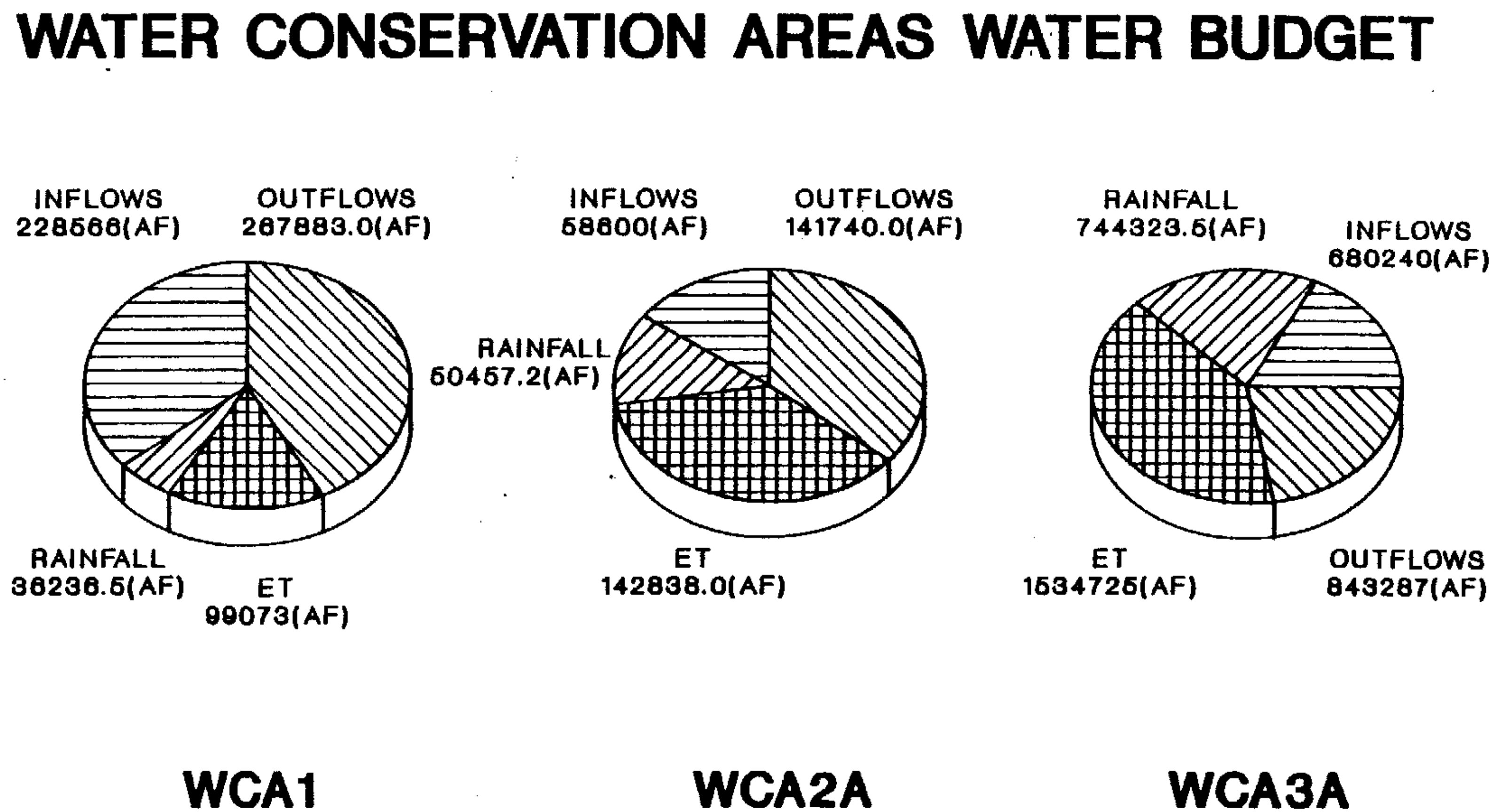


Figure 4.7 Water Conservation Areas Water Budget

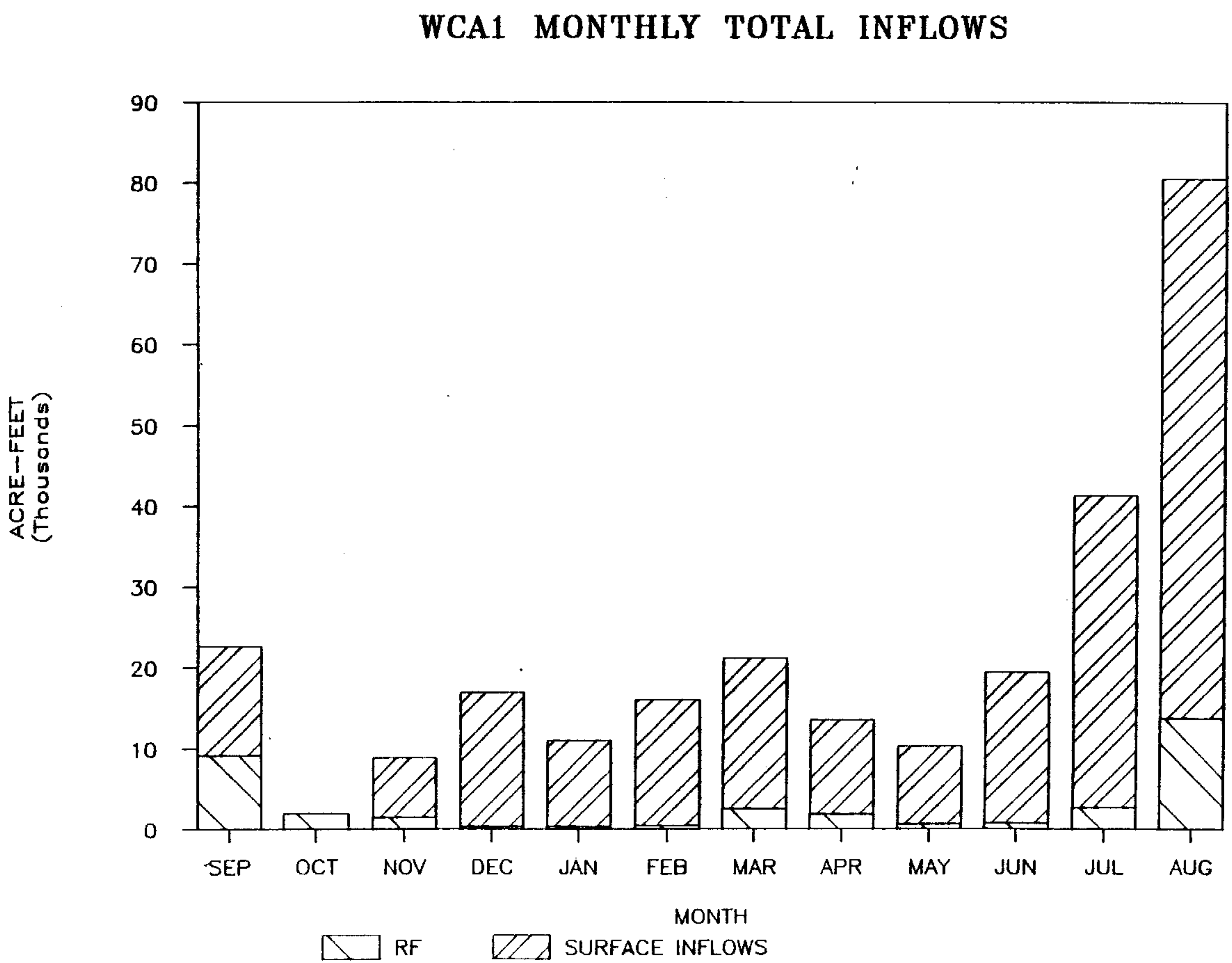


Figure 4 8 WCA 1 Monthly Total Inflows

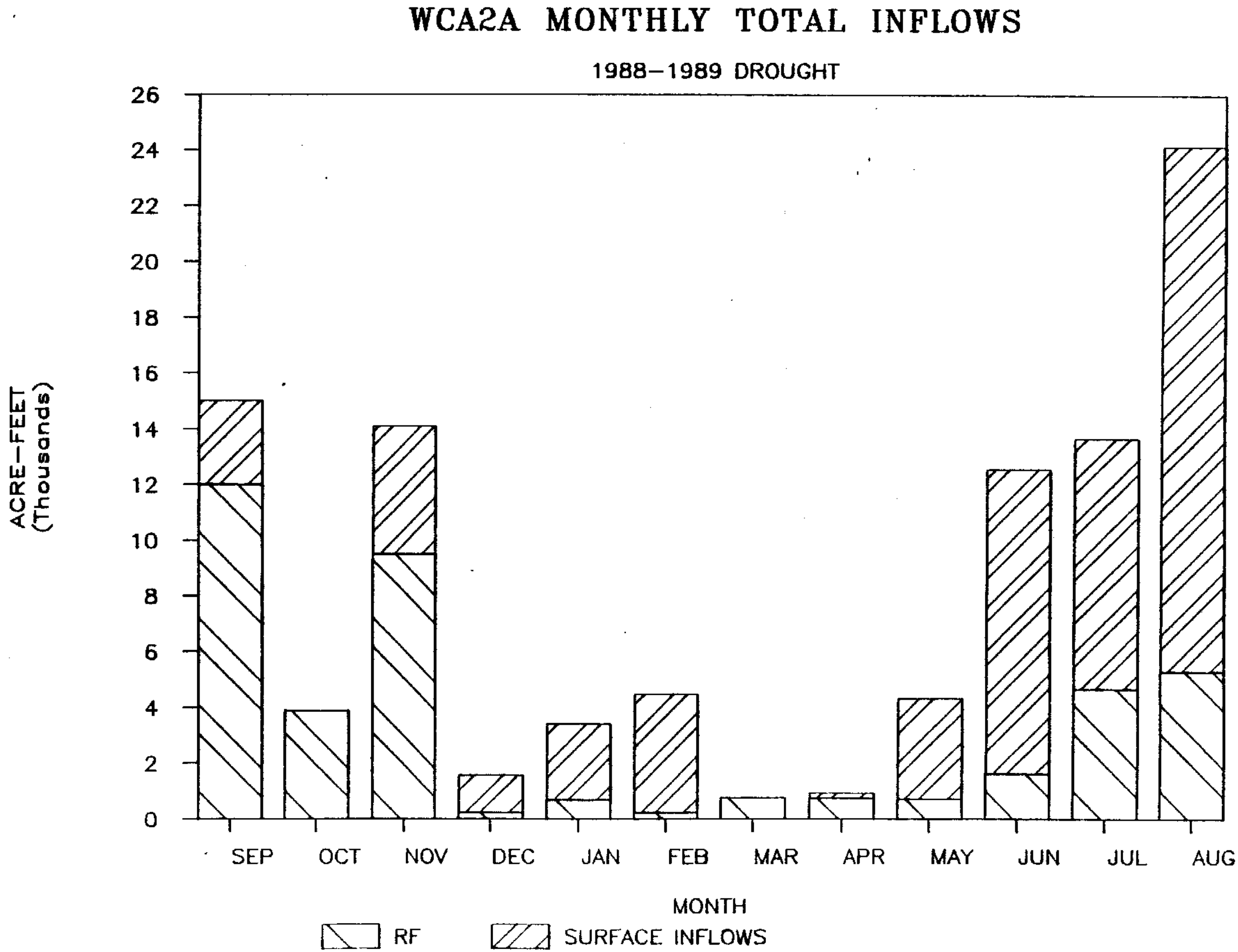


Figure 4 9 WCA 2A Monthly Total Inflows

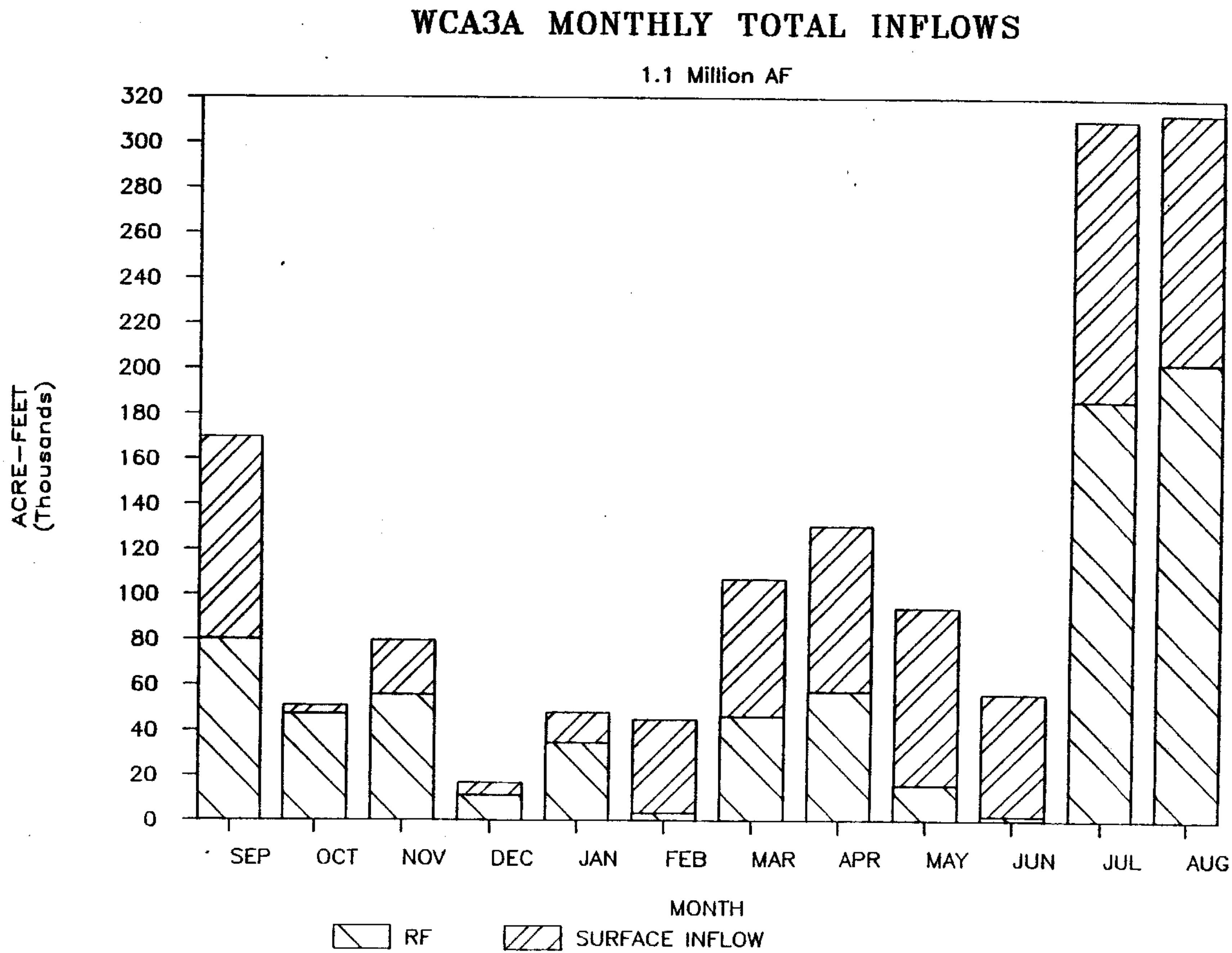


Figure 4 10 WCA 3A Monthly Total Inflows

5. WATER SUPPLY DISTRIBUTION

This section presents an analysis of the water supply releases from Lake Okeechobee and the Water Conservation Areas during the drought period of September 1988 through August 1989.

Lake Okeechobee

The water supply deliveries from Lake Okeechobee during the 12 month period beginning September 1, 1988 and extending through August 1989 were greatly increased compared to the water supply required during a normal rainfall year. Over two and a half times as much water was required for water use for this period compared to a normal year. The EAA demands increased from 450,000 AF of water for a normal RF year to 790,000 AF for the analysis period. This represents a net increase of 340,000 AF in water use. The other Lake subservice areas increased even more dramatically from 150,000 AF to 507,600 AF or a net increase of 357,000 AF. In addition, during a normal rainfall year the Water Conservation Areas are capable of supplying sufficient water to the Lower East Service Areas without receiving water from the Lake. However, in 1988-1989 the Lake delivered a volume of 310,000 AF of water to the Lower East Coast to maintain water levels in the canals for water use and to preclude the threat of saltwater intrusion.

The distribution of water supplied from the Lake appear in Figure 5-1. The EAA used about 50% of the water that was delivered from the Lake for water supply. The Lower East Coast received 18.6% of the water supply allocated from the Lake. The deliveries to the Caloosahatchee River and the St. Lucie Canal through the S-77 and S-308 structures respectively accounted for about 10% of the flows leaving the Lake. Of this volume of water about 60% was for water use within the C-43 and C-44 basins. C-43 basin was supplied with 178,000 AF of water, while C-44 basin received 51,000 AF from the Lake. The rest of the water went for salinity control. The Caloosahatchee had an estimated 43,000 AF delivered for salinity control while the St Lucie Estuary received 79,000 AF from the Lake.

The M Canal which supplies water to West Palm Beach received 71,490 AF and the C-51 canal received 47,430 AF from the Lake. These are unusually large deliveries of water because of the severity of the drought along coastal regions. The majority of the deliveries to the Lower East Coast went to Service Area 3. This service area received nearly 260,000 AF of the 310,000 AF delivered from the Lake.

Figure 5-2 illustrates the monthly distribution of water use from Lake Okeechobee. Substantial water supply releases were made to the Lake service area nearly every month of the year. Peak releases are made from the Lake during September and October 1988, and February through June 1989. The largest releases to the EAA were made in May and June. February was an unusual high winter water use month as rainfall was low over the EAA and temperatures were high. Drier weather along the coastal regions increased water use requirements for the Lake coastal subservice areas and the Lower East Coastal Service Areas. May was an extremely dry month for the area surrounding of the Lake. The EAA immediately south of the Lake required large releases. The Lake coastal subservice areas and the

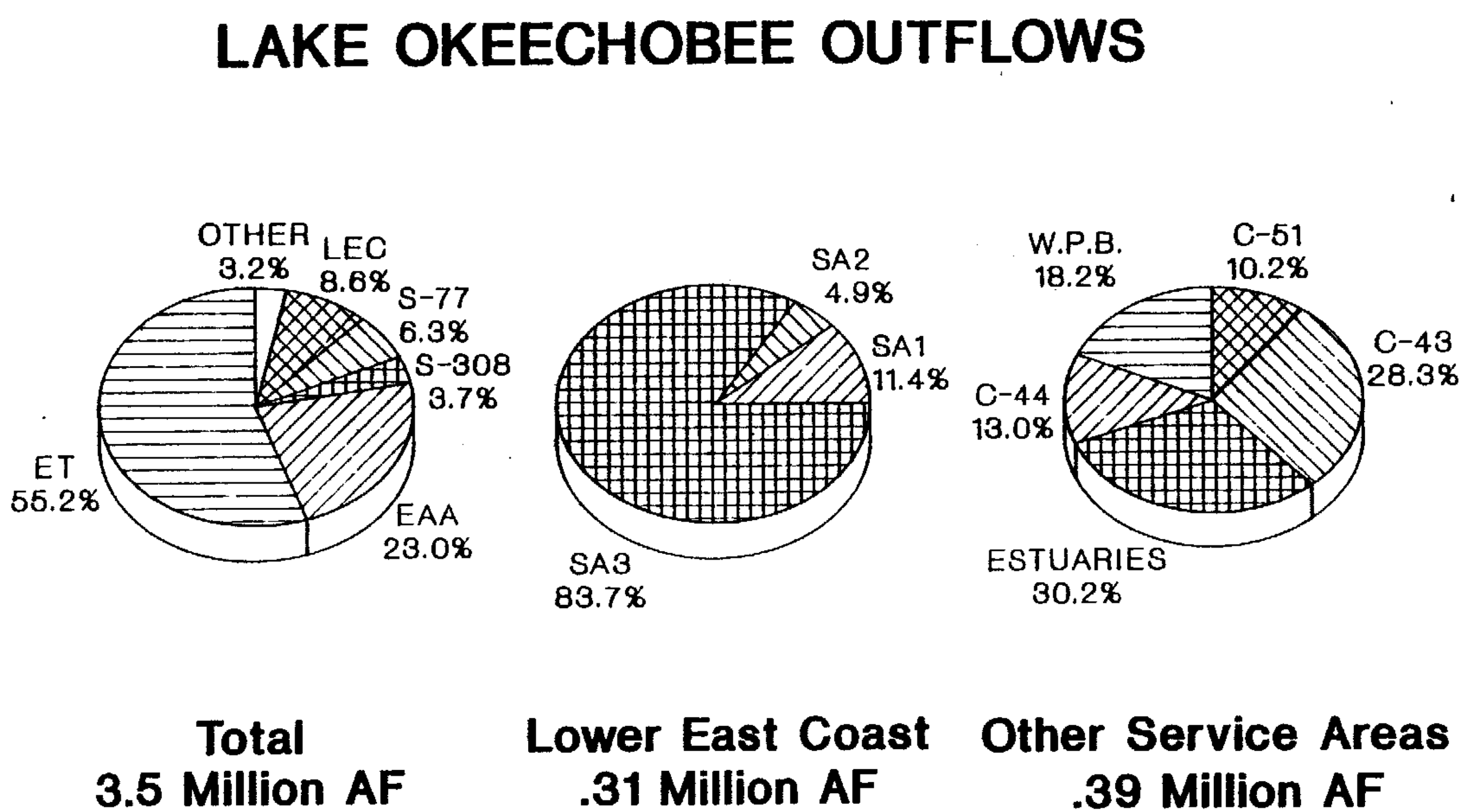


Figure 5-1 Lake Okeechobee Outflows

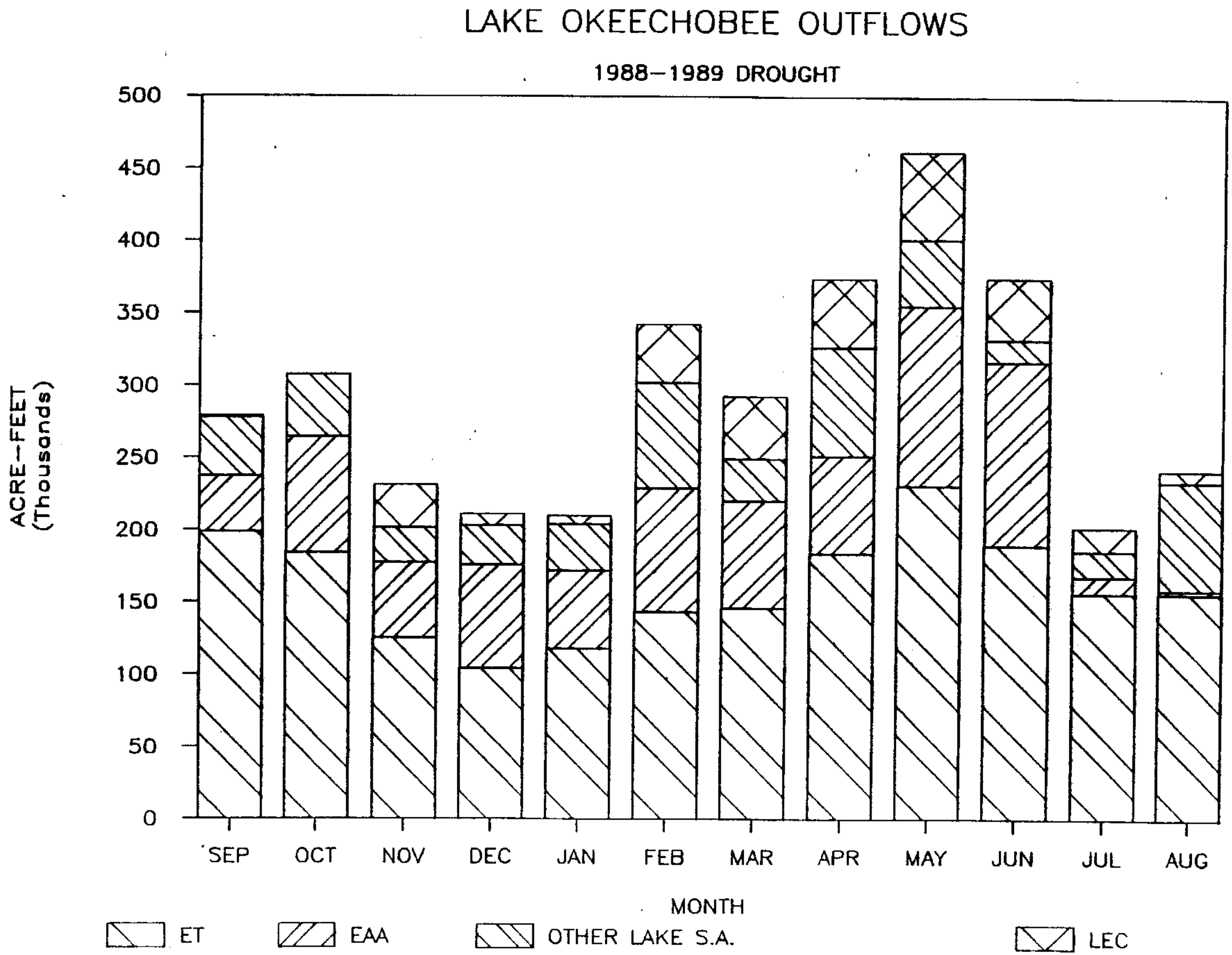


Figure 5.2 Lake Okeechobee Outflows 1988-1989 Drought

Lower East Coastal Service Areas also required large releases this month. In June, water use requirements remained high in the EAA. The Lake coastal subservice areas and the Lower East Coast Service Areas received enough rainfall to reduce their water use requirements on the Lake. However, it is unusual that they need water supply from the Lake at all during the wet season. Substantial releases to the Lower East Coast ended in July as coastal rainfall continue to become more plentiful. July had minimal releases from the Lake for water use. In August, water use increased in many of the Lake service areas. Runoff into the Lake was very small even with normal rainfall in August due to the very dry antecedent conditions. Normally the Lake receives large runoffs in the month of August. In summary, the losses due to ET are greater than all other outflows combined. Substantial releases were made to the Lake Service Areas almost every month. Peak releases are made during September and October in 1988 and February through June in 1989. The largest releases to the EAA were made in May and June in 1988-1989.

Water Conservation Areas

Water Conservation Area 1 made 79,733 AF of water supply releases through the S-39 to the Coastal Hillsboro Basin, 80,373 to the Lake Worth Drainage District (L-40) and 63,491 through the S-5A structure to the C-51 Canal or to through the M Canal to West Palm Beach. These flows illustrated in Figure 5-3. Figure 5-4 show the monthly distribution of outflow from WCA1. Water deliveries were made to the Lower East Coast Service Area 1, to the C-51 basin and the M Canal throughout the period. Surface water outflows are balanced by surface inflows to Water Conservation Area 1 so that the net change in storage appears to be due to ET and seepage losses being greater than rainfall. However when viewing the monthly inflows to WCA 1, that appear in Figure 5-5, it becomes obvious that a large portion of the inflow entered the area in August 1989 due to runoff from the EAA and the L-8 basin, well after the water supply deliveries were made from Water Conservation Area 1.

Water Conservation Area 2A had a computed loss in storage of 260,000 AF. ET and seepage account for a loss of 237,170 AF. Outflows were greater than inflows by 72,350 AF. Eastern Broward County received 17,482 AF through S-34 and 30,923 AF through S-38. This was mainly due to the regulatory releases made through the S-11 structures in September 1988. Figure 5-6 summarizes the inflows and outflows from WCA 2A. Seepage and ET are a substantial part of the budget. The monthly distribution of outflows from WCA 2A appears in Figure 5-7.

The water use releases compared to other inflows and outflows from WCA 3A appear in Figure 5-8. Water use releases are those made through structure S-151 to Dade County. A portion of the releases made to the Everglades National Park were regulatory. These were made in September 1988. The remainder of the releases were made to satisfy the delivery requirements to the Park described by the Rainfall Plan. During the 18 years that the minimum delivery schedule was in effect, the S-12 structures were never completely closed. The nine months that these structures were closed during this drought is the longest period the structures were ever closed.

The biggest user by far was the South Dade Conveyance System. Figure 5-9 illustrates the monthly distribution of outflows from WCA 3A. ET dominates as the largest outflow except in May and June when low stages shrink the surface area inundated by water. Figure 5-10 illustrates the sharp decline of releases to the Park. Figure 5-11 illustrates the water supply releases to Dade County. They are dominated by the releases to the South Dade Conveyance System. Table 5-1 illustrate historical regulatory and water use releases to South Dade. Since the South Dade Conveyance System has come into operation in the early 1980's, water supply releases have dramatically increased through the S-151 structure. 1988-1989 had by far the largest volume of releases for a two year period. Figure 5-12 summarizes the releases to the Lower East Coast Service Area 3.

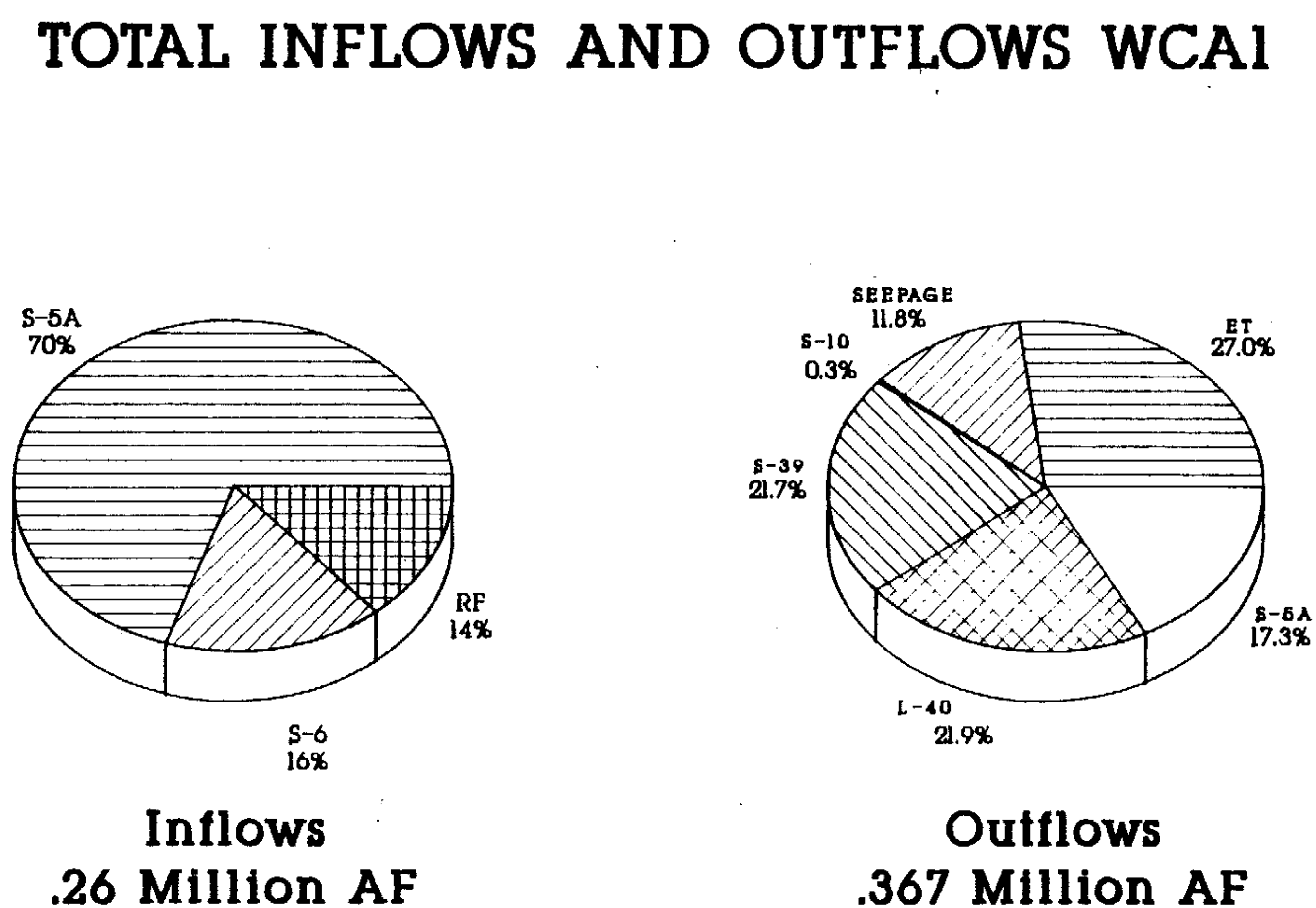


Figure 5-3 Total Inflows & Outflows WCA 1

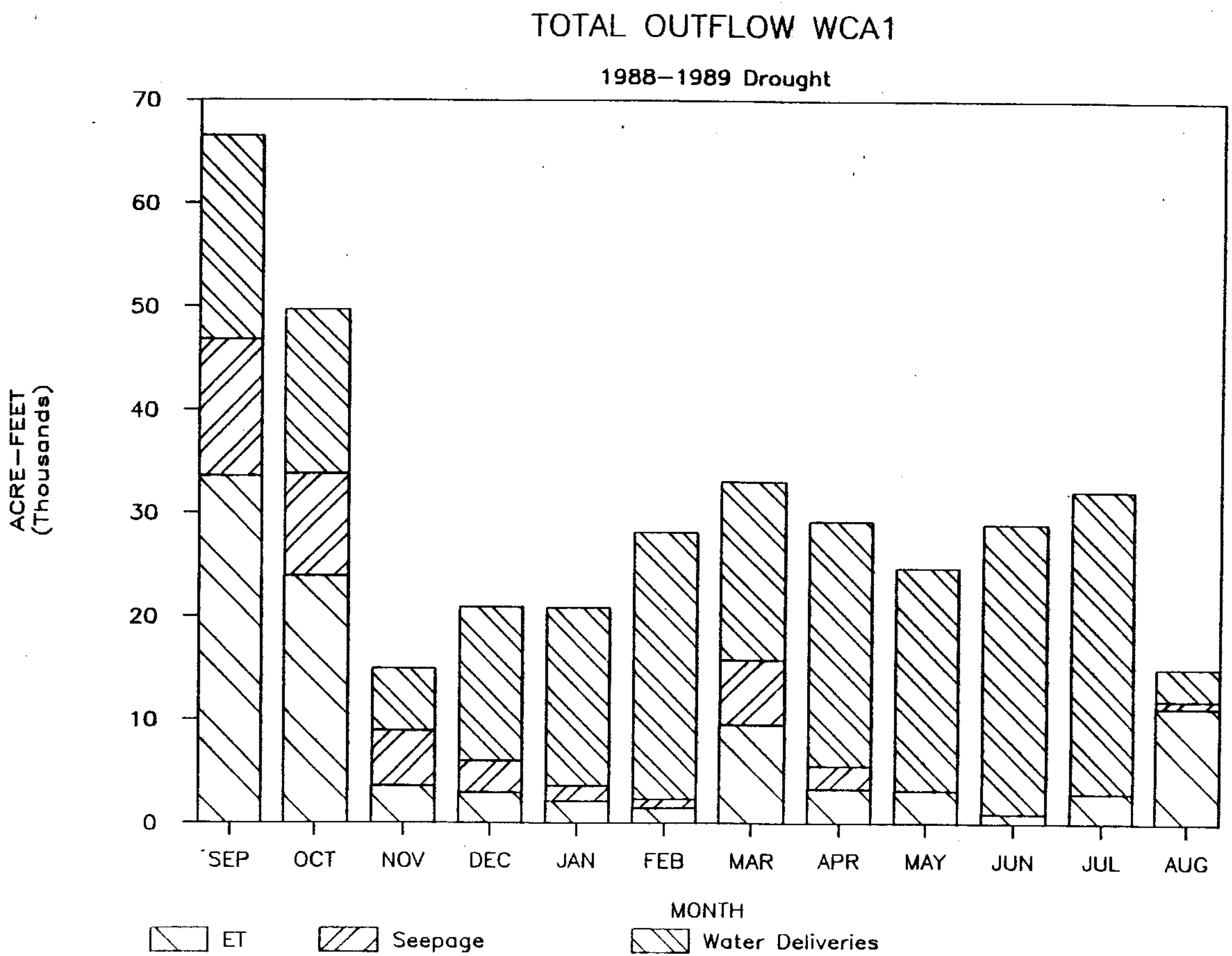


Figure 5-4 Total Outflow WCA 1 1988-1989 Drought

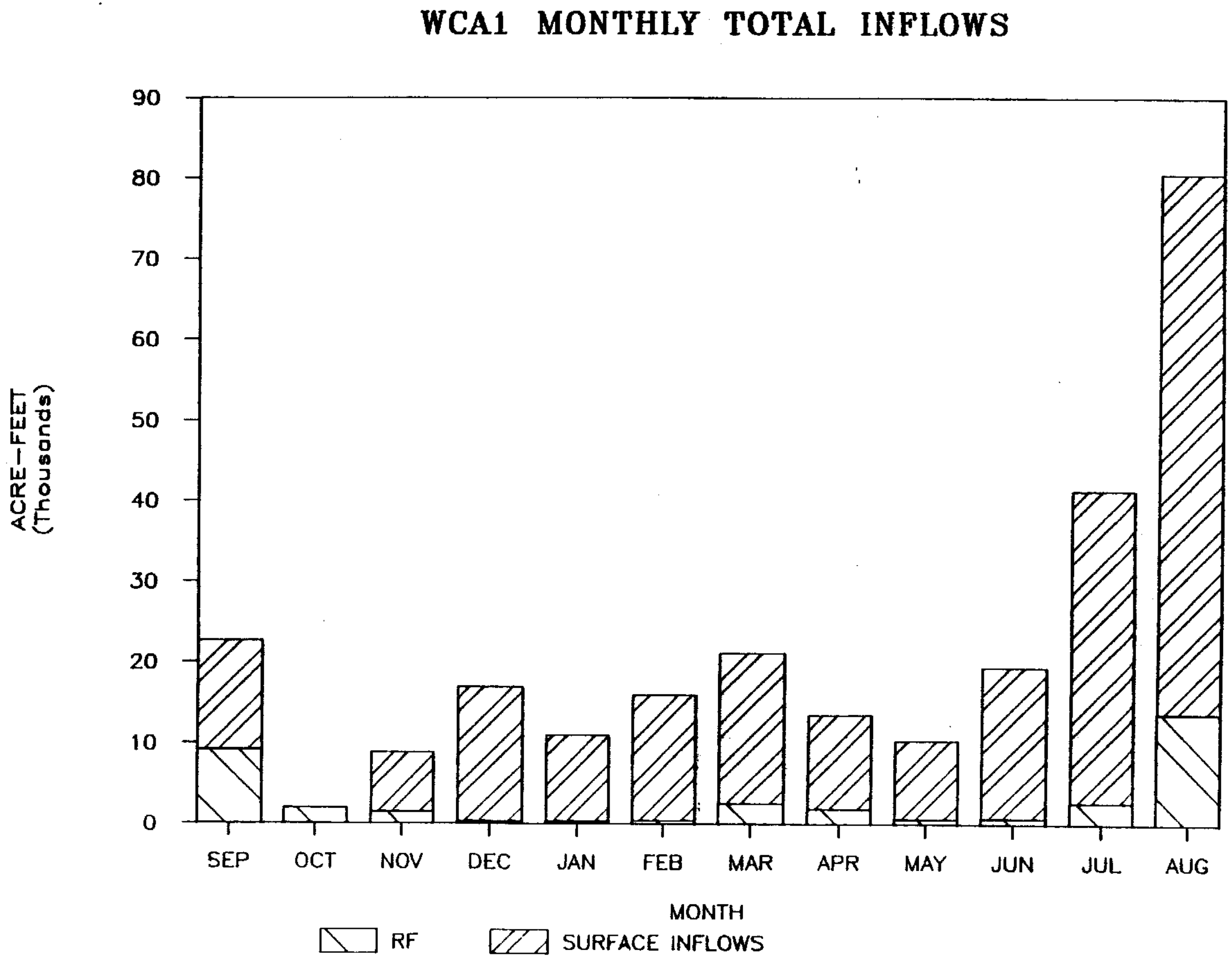


Figure 5.5 WCA 1 Inflows

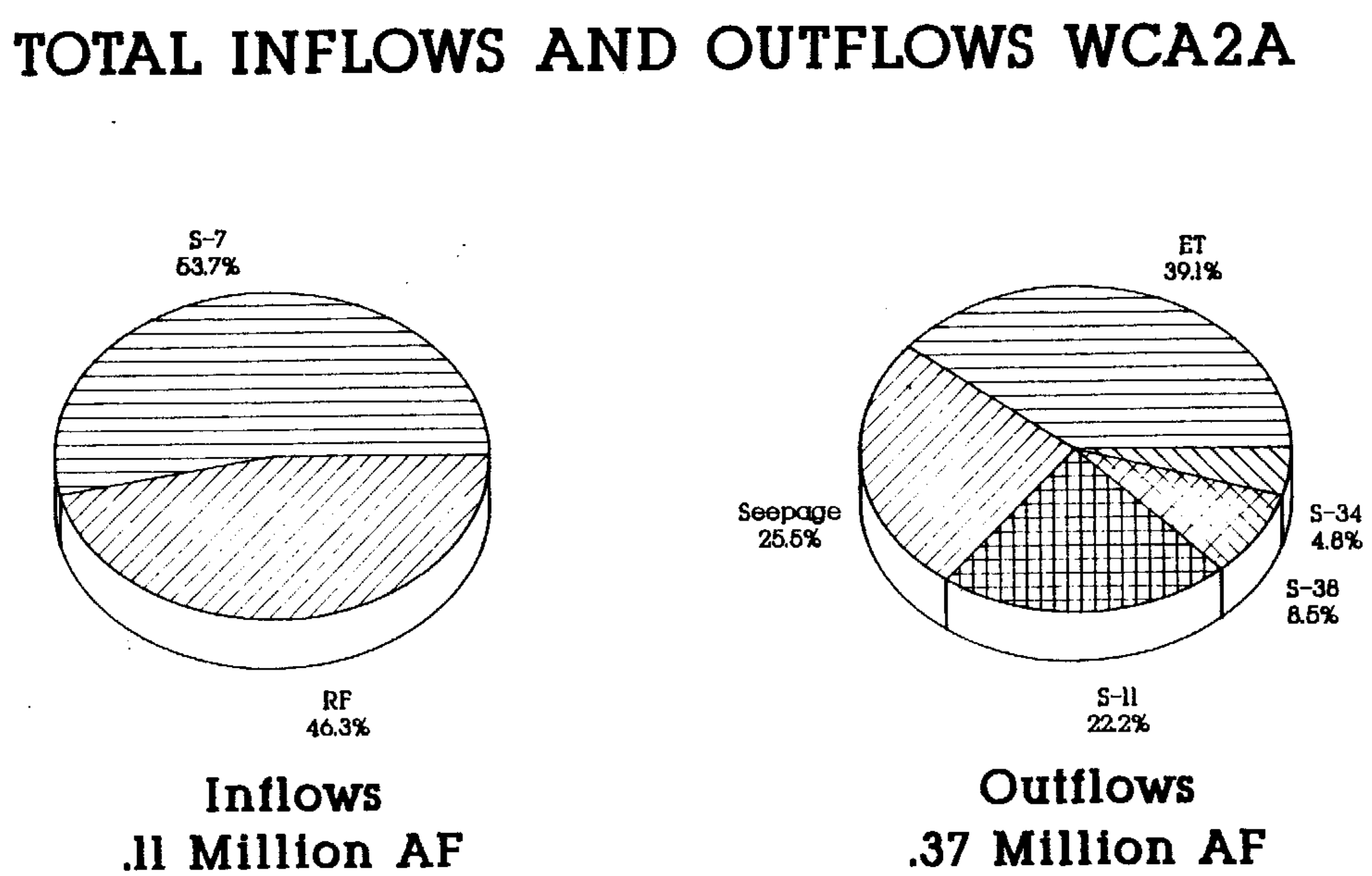


Figure 5-6 Total Inflows & Outflows WCA 2A

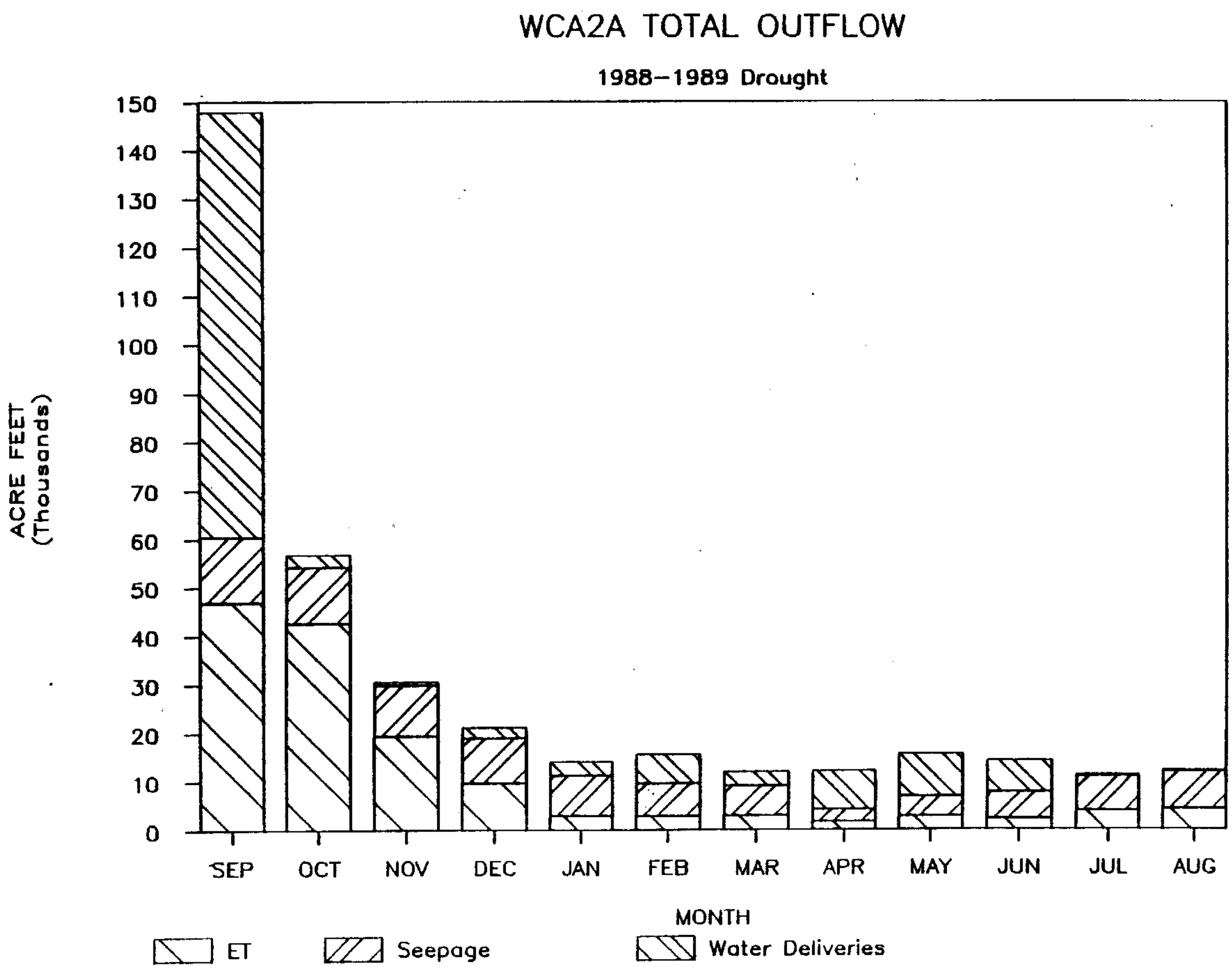


Figure 5-7 WCA 2A Total Outflow 1988-1989 Drought

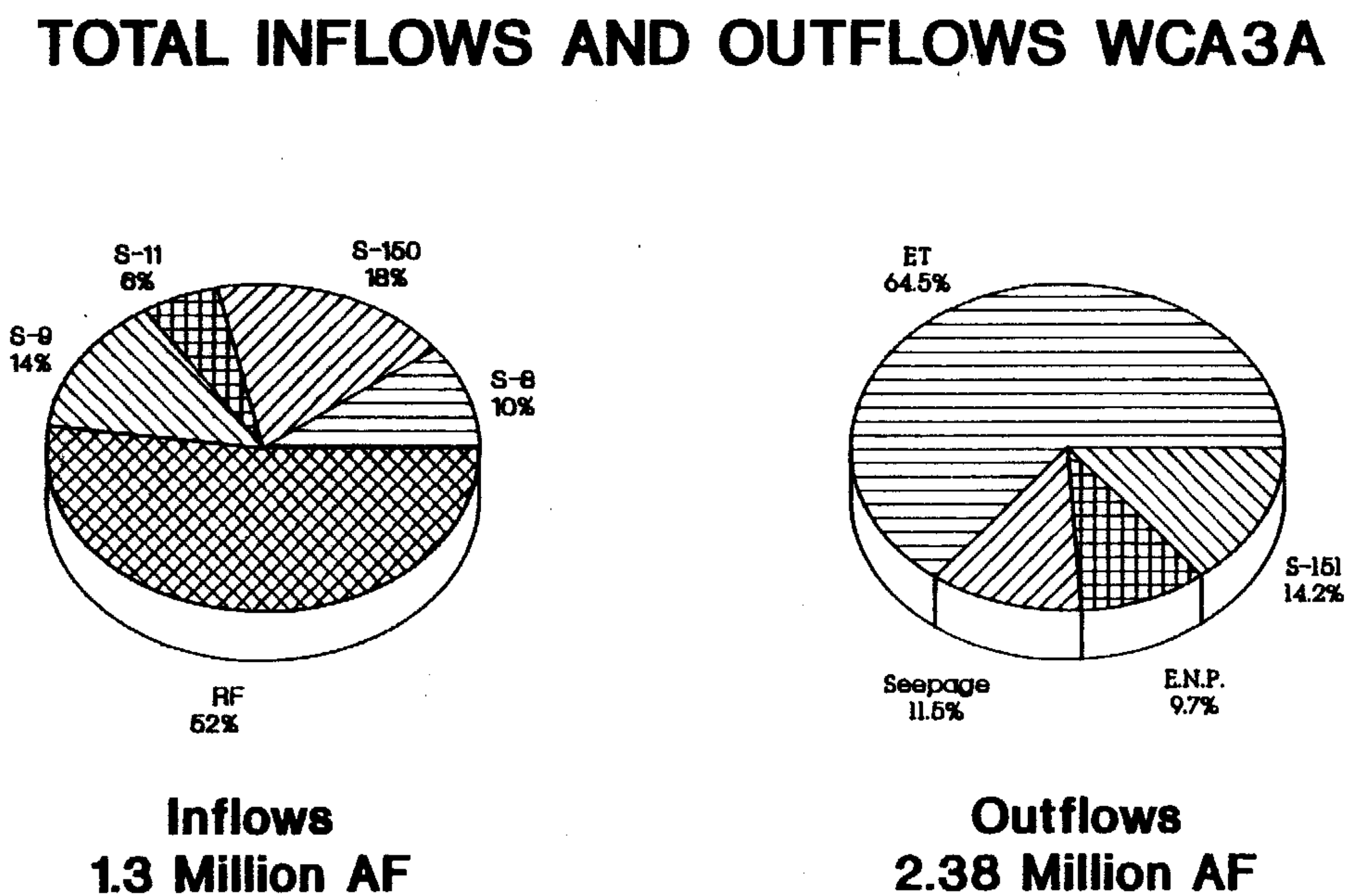


Figure 5-8 Total Inflows & Outflows WCA 3A

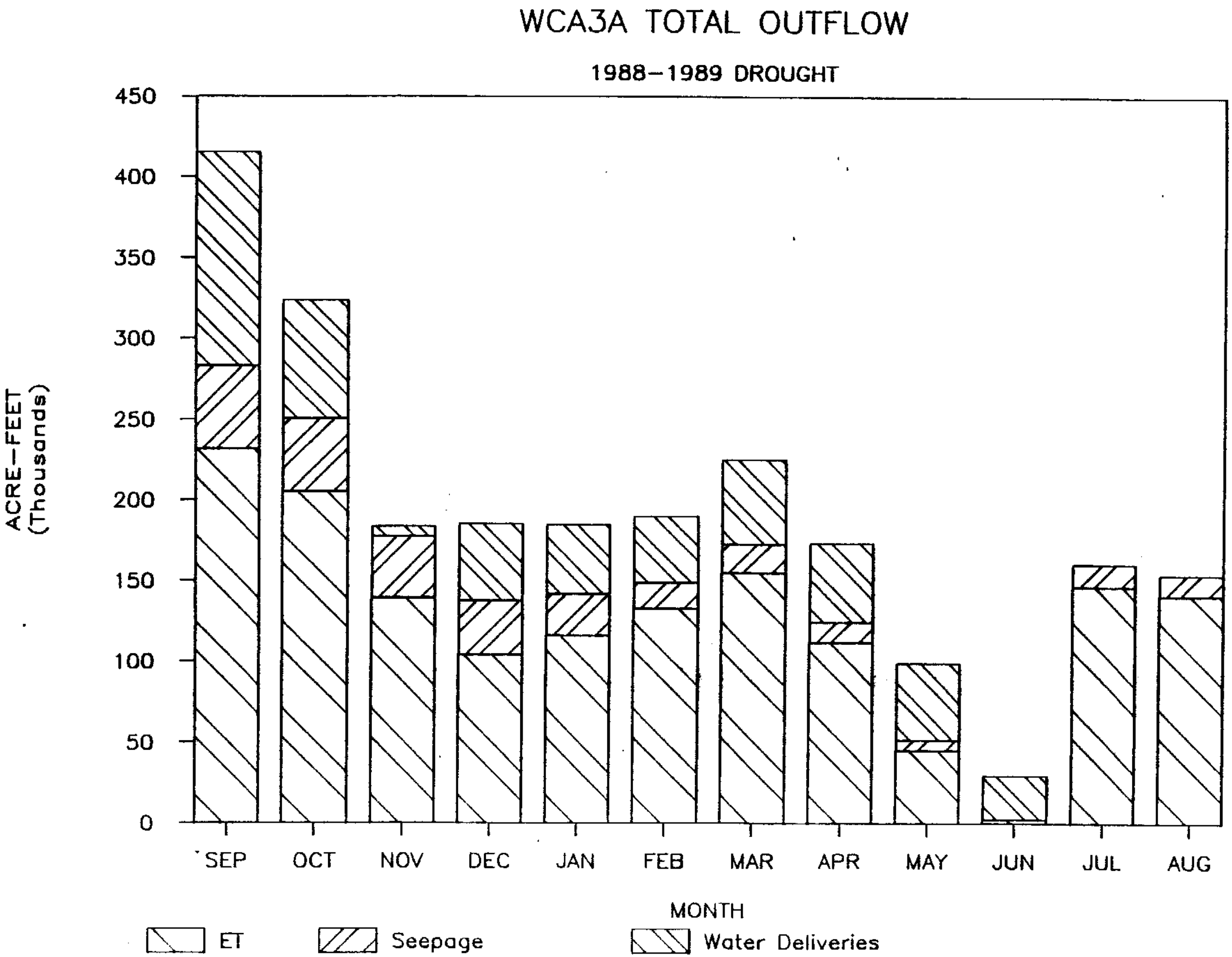


Figure 5-9 WCA 3A Total Outflow 1988-1989 Drought

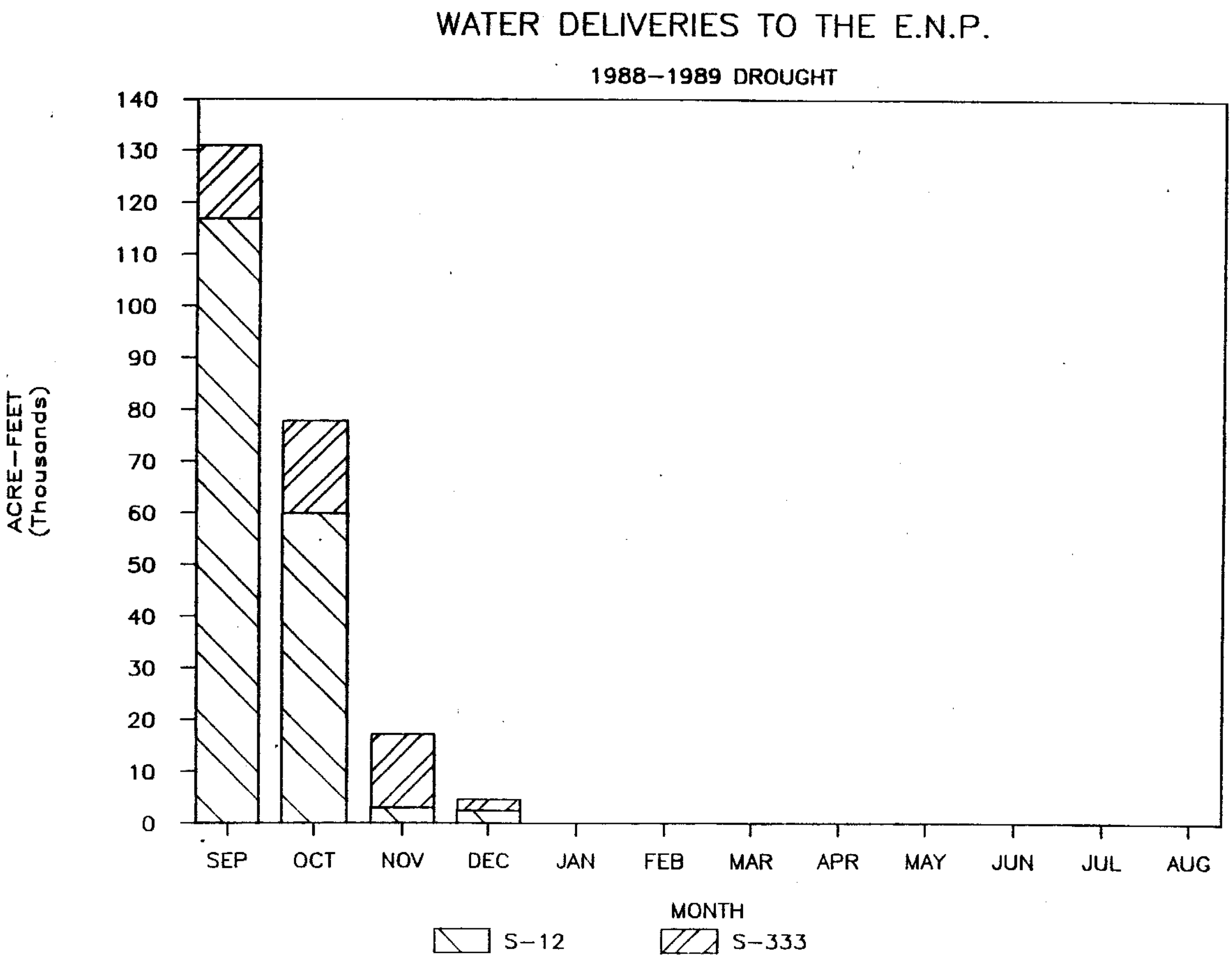


Figure 5-10 Water Deliveries to the ENP 1988 1989 Drought

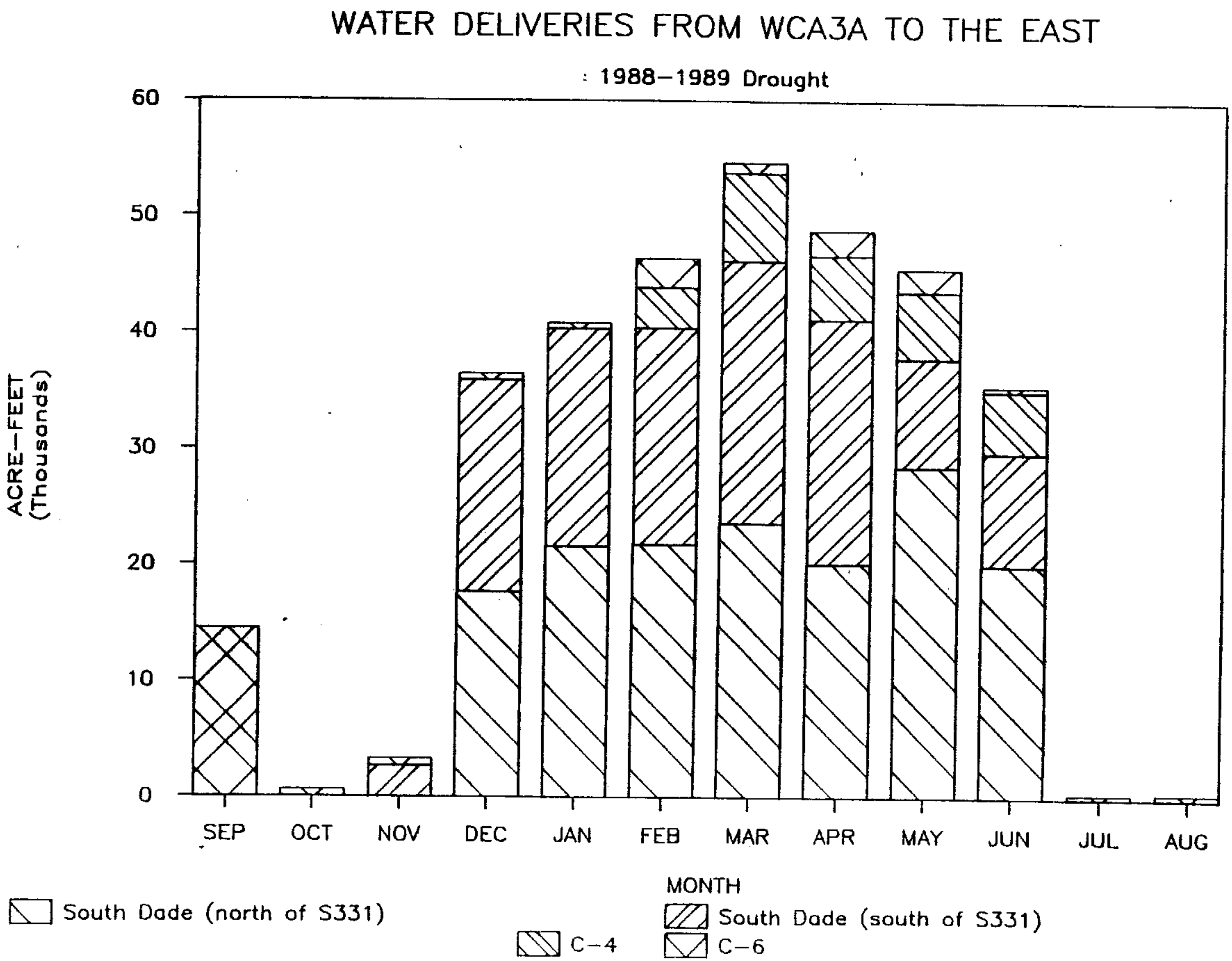


Figure 5-11 Water Deliveries from WCA 3A to the East 1988-1989 Drought

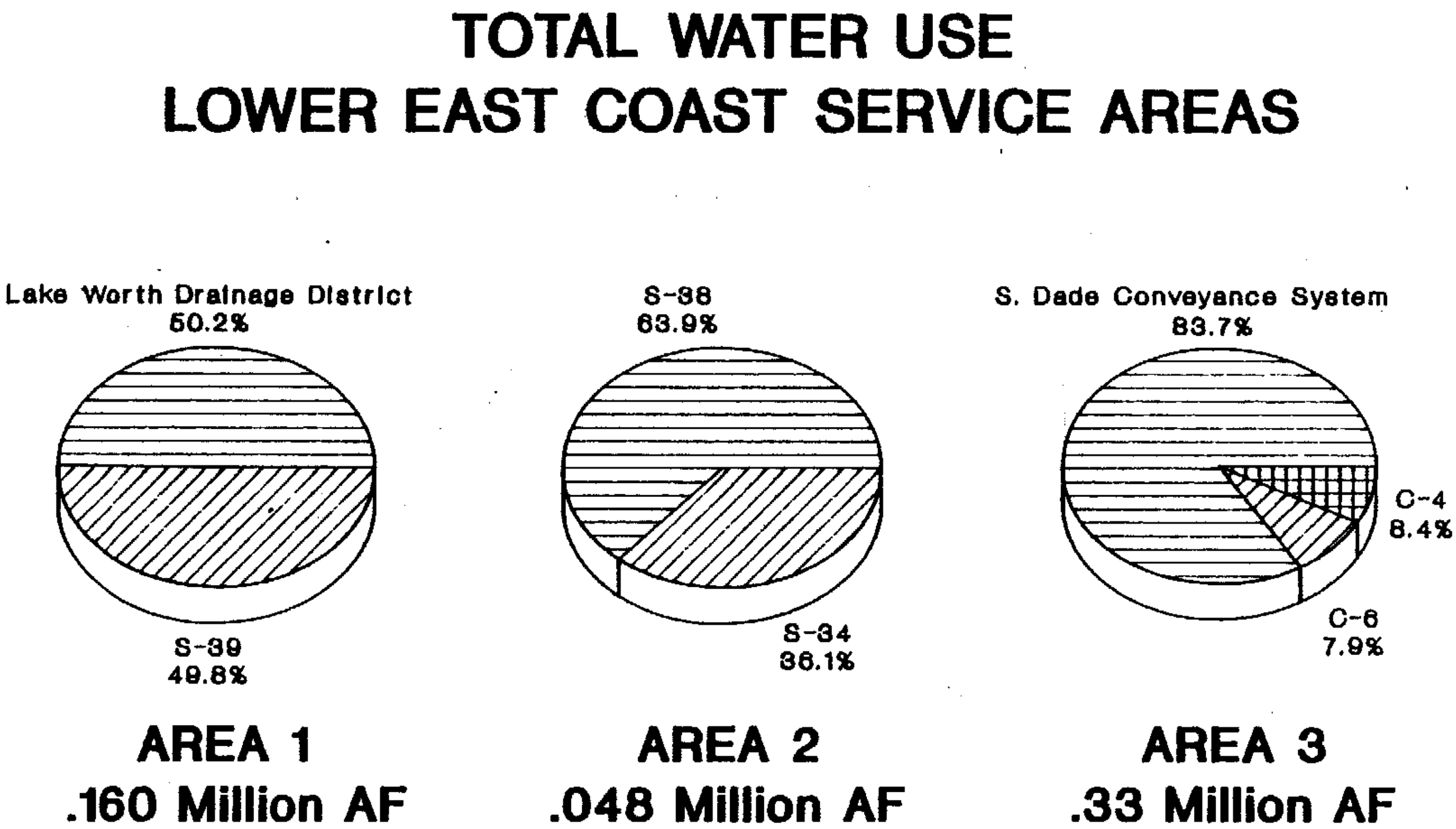


Figure 5-12 Lower East Coast Service Area 3 Total Water Use of 3.3 Million Acre-Feet

TABLE 5-1
S-151 Discharges in Acre-Feet
Period of Record: January 1962-August 1989

	Water Supply	Flood Control		Water Supply	Flood Control
1962	12,100	0	1976	14,800	0
1963	500	0	1977	5,500	0
1964	0	0	1978	0	90,700
1965	4,800	0	1979	0	93,350
1966	20	129,000	1980	106.512	0
1967	0	0	1981	55,750	0
1968	0	0	1982	15,000	153,350
1969	150	0	1983	32,300	360,400
1970	0	164,500	1984	119,346	19,200
1971	19,600	0	1985	126,510	60,232
1972	0	0	1986	68,000	216,500
1973	13,300	0	1987	64,000	62,200
1974	55,800	0	1988	202,200	78,700
1975	26,750	0	1989	261,303	to August 1989

7. SUMMARY AND CONCLUSIONS

Conclusions

1. The rainfall deficiency experienced during the period of September 1988 through August 1989 was 13 inches throughout the District. This represents a return period of 50 years.

2. The drought was particularly severe in the Everglades Agricultural Area (EAA) and the Lower East Coast where rainfall deficiencies were in each case over 20 inches. This represents a return period of over 100 years in the EAA and over 50 years in the Lower East Coast.

3. Loss in storage in Lake Okeechobee and the Water Conservation Areas was at a record high for this period.

4. The entire surface water supply system experienced a record 3.1 million acre-feet in losses during this drought.

5. Water releases from Lake Okeechobee were 790,000 acre-feet to the EAA, and 310,000 acre-feet to the Lower East Coast. These releases were much larger than normal due to an increase in demand generated by the below normal rainfall conditions.

6. The Water Conservation Areas experienced record low stages during this period. WCA 1 was 5 feet below the historical average during January and February while WCA 3A was 4 feet below the historical average in June.

7. The Everglades National Park (ENP) experienced lack of rainfall and received very low releases from WCA 3A. The ENP did not receive any flow from January through August. The nine months the S-12 structrues were closed during this drought is the longest period of zero flow to the ENP on record.

APPENDIX 1

DESCRIPTION OF THE SYSTEM AND OPERATIONAL CONSTRAINTS

This section describes the primary hydrologic basins that require water supply from Lake Okeechobee. It also describes the Water Conservation Area system and the Everglades National Park. The location of these are shown in Figures A-1 and A-2. The operational constraints are also addressed in this section.

S-3 Basin, Miami Canal

The S-3 drainage basin is 101.0 square miles in area and is located in west-central Palm Beach County (66.2 square miles) and east-central Hendry County (34.8 square miles).

The Project canals and water control structures affecting flow in the S-3 basin have five primary functions: (1) to remove excess water from the S-3 basin to storage in Water Conservation Area 3A (WCA 3A) , and under some flood conditions to storage in Lake Okeechobee; (2) to prevent over drainage of the S-3 basin; (3) to supply water from Lake Okeechobee to the S-3 and S-8 basins as needed for irrigation; (4) to provide conveyance for regulatory releases from Lake Okeechobee to be passed to storage in WCA 3A and for water supply releases from the lake to be passed to eastern Dade County and Everglades National Park; and (5) to receive discharges of excess water from the L-1 borrow canal (i.e., northeast Hendry County) when these discharges will not jeopardize flood control in the S-3 or S-8 basins. Pump stations S-3 and S-8 remove excess water from the S-3 basin and discharge it to Lake Okeechobee and WCA 3A respectively. Regulatory releases from Lake Okeechobee will be able to be made to the Miami Canal by way of S-354 after a projected completion date of April 13, 1990. On the rare occasions such releases are made, they are passed to WCA 3A by way of S-8. Water supply releases from Lake Okeechobee are made to the Miami Canal by way of S-354 from Hurricane Gate 3, which is presently under construction, and S-3. These releases are passed to WCA 3A, and subsequently to eastern Dade County and Everglades National Park, by way of S-8. Discharges from the L-1 borrow canal are made to the L-1E canal and subsequently to the Miami Canal.

The Miami Canal is the only Project canal in the S-3 basin. Two non-Project canas are important to the primary system in the basin. One is the Bolles Canal, built prior to the Project by the Everglades Drainage District, and the other is the L-1E canal built by the District from 1982 to 1987.

The Miami Canal connects Lake Okeechobee to WCA 3A. The connection to Lake Okeechobee is by way of S-3 and S-354 at the north end of the canal at the town of Lake Harbor. The connection to WCA 3A is by way of S-8, 15 miles west of U.S. Highway 27 on the Broward-Palm Beach County line.

Outlet capacity at S-354 due to present construction is limited to the capacity of four 60 inches x 160 feet corrigated metal pipe (CMP) culverts plus some syphoning through the S-3 pump.

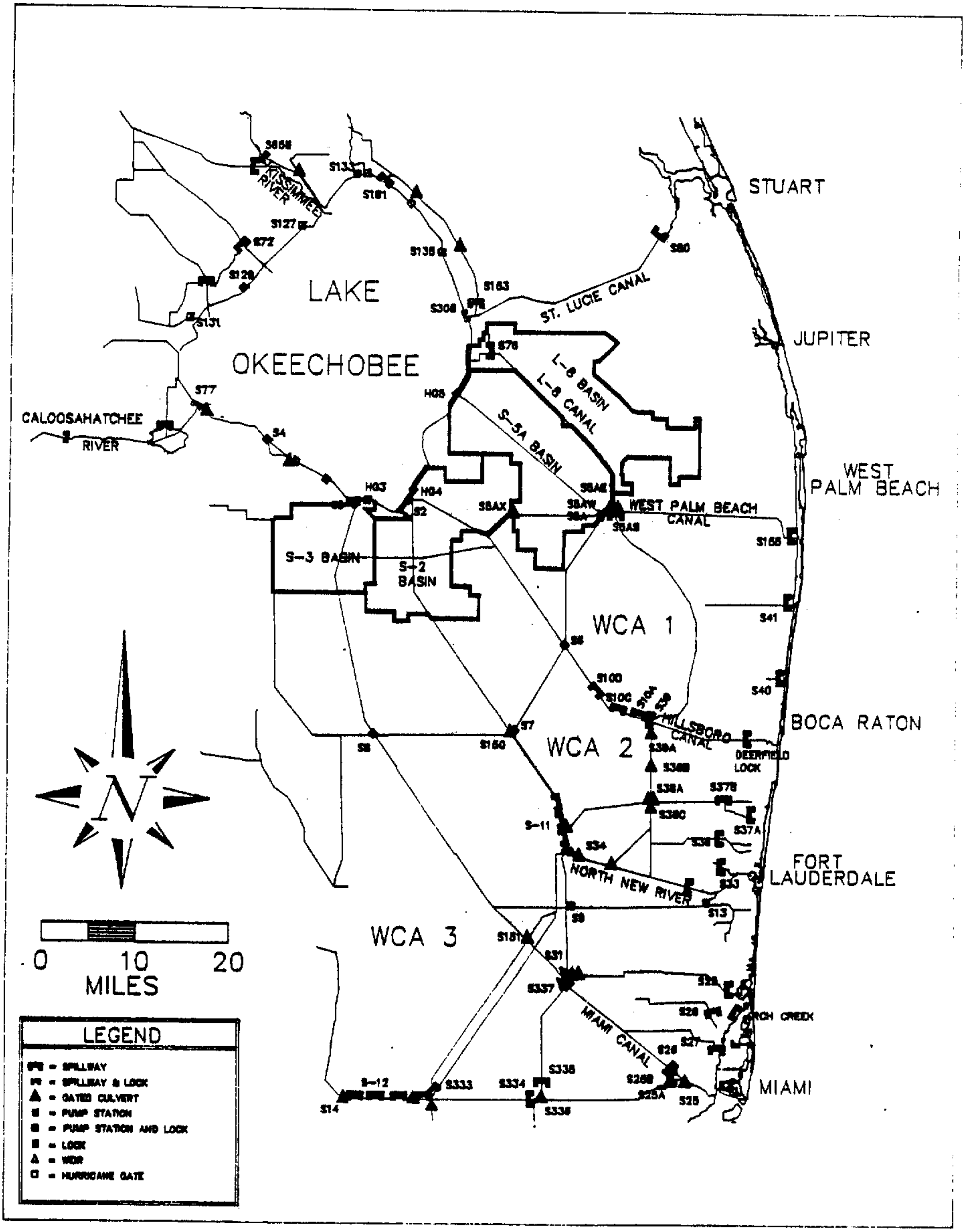


Figure A-1 Lake Okeechobee & Water Conservation Supply System

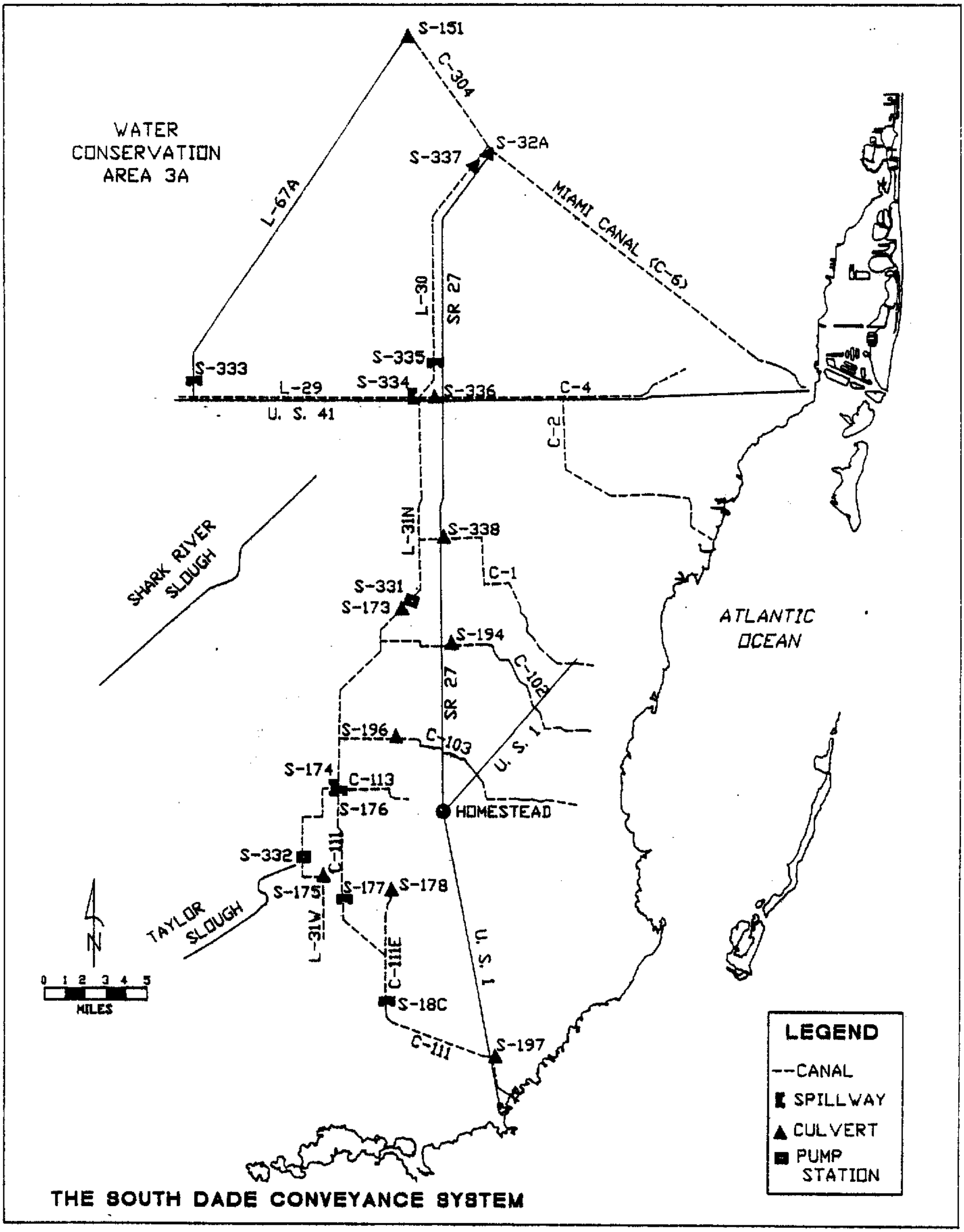

S-151
C-304
WATER
CONSERVATION
AREA 3A
S-32A
S-337
L-67A
MIAMI CANAL (C-6)
L-30
SR 27
S-333
S-335
L-29
S-334
S-336
C-4
U. S. 41
C-2
SHARK RIVER
SLOUGH
L-31N
S-338
C-1
S-331
S-173
ATLANTIC
OCEAN
S-194
C-102
SR 27
S-196
C-103
U. S. 1
S-174
C-113
S-176
HOMESTEAD
S-332
C-111
S-175
S-177
S-178
TAYLOR
SLOUGH
L-31W
C-111E
U. S. 1
N
0 1 2 3 4 5
MILES
S-18C
C-111
S-197
LEGEND
---CANAL
SPILLWAY
CULVERT
PUMP
STATION
THE SOUTH DADE CONVEYANCE SYSTEM

Figure A-2

At a Lake Okeechobee stage of 11.5 feet msl, the four culverts have a capacity of 400 cfs with 1.5 feet head loss. At the same time additional 540 cfs could be symphoned through S-3. When the lake stage drops below 10.5 feet msl, the 1.5 feet head loss at S-3 will not be available; therefore, there would be very little water available to supply WCA 3A.

After completion of S-354, with a Lake stage of 10.5 feet and a canal stage of 10.0 feet, 1,300 cfs can be discharged.

S-2 Basin, North New River and Hillsboro Canals

The S-2 drainage basin is 165.7 square miles in area and is located in west-central Palm Beach County.

The Project canals and water control structures affecting flow in the S-2 basin have four primary functions: (1) to remove excess water from the S-2 basin to storage in the Water Conservation Areas (WCAs), and under some flood conditions, to storage in Lake Okeechobee; (2) to prevent overdrainage of the S-2 basin; (3) to supply water from Lake Okeechobee to the S-2, S-6, and S-7 basins as needed for irrigation; and (4) to provide conveyance for regulatory releases from Lake Okeechobee to be passed to storage in the WCAs and for water supply releases from the lake to be passed to eastern Palm Beach and Broward counties. Pump stations S-2, S-6, and S-7 remove excess water from the S-2 basin and discharge it to Lake Okeechobee, WCA 1, and WCA 2A, respectively. Under some rare flood conditions, S-351 may discharge to Lake Okeechobee. S-150 allows gravity discharge to WCA 3A from the S-2 basin by way of the North New River Canal. Regulatory releases from Lake Okeechobee are made to the Hillsboro and North New River canals by way of S-351, formerly Hurricane Gate 4. On the rare occasions such releases are made, they are passed to WCA 1 by way of S-6, to WCA 2A by way of S-7, and to WCA 3A by way of S-150. Water supply releases from Lake Okeechobee are made to the Hillsboro and North New River Canals by way of S-351 and S-2. These releases are passed to the WCAs, and subsequently to eastern Palm Beach and Broward counties, by way of S-7 and on some occasions S-6.

There are two Project canals in the S-2 basin: the Hillsboro Canal and the North New River Canal. Two other, non-Project canals are important in the basin. These are the Bolles Canal and the Cross Canal. The Cross Canal is tributary to the Hillsboro Canal and the Bolles Canal is tributary to both the Hillsboro and the North New River canals.

The Hillsboro Canal connects Lake Okeechobee to WCA 1. The connection to Lake Okeechobee is by way of S-2 at the north end of the canal at South Bay west of Belle Glade. The connection to WCA 1 is by way of S-6 at the intersection of L-6 and L-7 on the west side of WCA 1.

The North New River Canal connects Lake Okeechobee to WCAs 2A and 3A. The connection to Lake Okeechobee is by way of S-2 at the north end of the canal at South Bay west of Belle Glade. The connection with WCA 2A is by way of S-7 at the intersection of L-5 and L-6, just east of U.S. Highway 27 on the Palm Beach-Broward County line. The connection with WCA 3A is by way of S-150 just west of S-7.

During the last dry season experience at S-150 indicated that for April and May the average tailwater stage at S-150 was 10.3 feet msl and the average discharge equaled 700 cfs. Lake Okeechobee stage would need to be approximately 11.0 feet msl to supply 700 cfs. As Lake Okeechobee stage drops below 11.0 feet msl, the headwater stage at S-150 will drop to 10.0 feet msl or less and the discharge will drop to something less than 500 cfs. At these lower stages additional flow might be obtained by pumping S-7 and releasing flow to WCA-3A via the S-11 structures.

It would appear that as the lake stage drops below 11.0 feet msl, the flow south to Dade County will be very limited.

S-5A Basin

The S-5A drainage basin is 194.3 square miles in area and is located in northwestern Palm Beach County. The basin boundary relative to local roads and landmarks is shown on Map A.

The Project canals and water control structures in the S-5A basin have four primary functions: (1) to remove excess water from the S-5A basin to storage in Water Conservation Area 1 (WCA 1), and under some flood conditions, to storage in Lake Okeechobee; (2) to prevent over drainage of the S-5A basin; (3) to supply water from WCA 1, Lake Okeechobee, or the L-8 basin to the S-5A basin for irrigation; and (4) to provide conveyance for regulatory releases from the Lake Okeechobee to WCA 1 and for water supply releases from the lake to the C-51 basin for municipal and agricultural use and to maintain the optimum canal water level to prevent saltwater intrusion. Excess water is usually discharged from the basin to WCA 1 by way of S-5A. Under some very rare conditions, water can be discharged from the basin to Lake Okeechobee by way of S-352. Regulatory releases from Lake Okeechobee can be made to the L-10/L-12 borrow canal (i.e., the West Palm Beach Canal) by way of S-352. On the rare occasions such releases are made, they are passed to WCA 1 by way of S-5A or S-5AS. Water is supplied to the basin from Lake Okeechobee by way of S-352, from WCA 1 by way of S-5AS and S-5AW, and from the L-8 borrow canal by way of S-5AW. It is possible, though unlikely, to transfer water from WCA 1 to Lake Okeechobee by way of the L-10/L-12 borrow canal. Under the rare circumstances that would make such a transfer possible and desireable, the L-8 borrow canal more likely would be used to make the transfer.

L-8 Basin

The L-8 drainage basin is 171.2 square miles in area and is located in northwestern Palm Beach County (168.1 square miles) and southwestern Martin County (3.1 square miles).

The Project canals and water control structures in the L-8 basin have four primary functions: (1) to protect the agricultural areas to the southwest of the L-8 basin by intercepting surface water flows originating in the L-8 basin, (2) to remove excess water from the L-8 basin to storage in either Lake Okeechobee or Water Conservation Area 1 (WCA 1), (3) to supply water from Lake Okeechobee or WCA 1 to the L-8 basin for irrigation of agricultural lands, and (4) to transfer water from storage in WCA 1 to Lake Okeechobee. Excess water can be discharged from the L-8 basin in one of three ways: (1) to Lake Okeechobee by way of Culvert #10A; (2) to tidewater by way of S-5AE; and (3) to WCA 1 by way of either S-5AS, or S-5AW and S- 365A. Water is supplied to the L-8 basin from Lake Okeechobee by way of Culvert #10A, from WCA 1 by way of S-5AS, and from the S-5A basin by way of S-5AW. The L-8 borrow canal is used to transfer water from storage in WCA 1 to storage in Lake Okeechobee. These transfers are made by gravity flow from the WCA through S-5AS to the borrow canal and are subsequently discharged to the lake by way of Culvert #10 A. The conditions that make such a transfer desirable and possible rarely occur.

The Project canals and water control structures in the basin have two secondary functions: (1) to supply water from the L-8 basin, WCA 1, or Lake Okeechobee to the City of West Palm Beach water supply system and (2) to accept discharges of excess water from the West Palm Beach water supply system. Water is supplied to the City of West Palm Beach municipal water supply system from the L-8 basin by way of a city owned and operated pump station located at the junction of the L-8 Tieback Levee borrow canal and the City of West Palm Beach's "M" Canal. A spillway adjacent to this pump station discharges excess water from the "M" Canal to the L-8 basin.

As Lake okeechobee stage drops below 11.0 msl, it becomes difficult to supply water to the City of West Palm Beach pump station at a stage that the city can operate its pumps. Elimination of the sheetpile weir at the entrance to the L-8 tieback borrow canal will help to operate the flap-gate that allows water to enter the borrow canal.

Water Conservation Area 1

The Water Conservation Area 1 (WCA 1) basin has an area of 220.3 square miles and is located in south-central Palm Beach County. WCA 1 is also known as the Auther R. Marshall Loxahatchee National Wildlife Refuge.

WCA 1 and its associated Project structures have five primary functions: (1) to provide viable wetland habitat (i.e, the WCA is managed insofar as possible as a natural Everglades system), (2) to detain and store flood and drainage water during the wet season for water supply during the dry season, (3) to prevent floodwater accumulating in the Everglades from flooding urban and agricultural lands in Eastern Palm Beach County, (4) to receive and store regulatory releases from Lake Okeechobee, and (5) to provide conveyance for water supply releases from Lake Okeechobee to the Hillsboro Canal basin. Inflows to the WCA are from local rainfall, from the S-5A, L-8, and C-51 basins by way of S-5A and S-5AS, from the S-2 and S-6 basins by way of S-6, and from Lake Okeechobee by way of the L-10/L-12 borrow (i.e., the West Palm Beach Canal), the L-8 borrow, and the Hillsboro canals. When required by the WCA 1 regulation schedule excess water is discharged to WCA 2A by way of the four S-10 structures, to the Hillsboro Canal by way of S-39, and to C-51 by way of S-5AS and S-5AE. The S-10 structures provide the principal means of discharging water from WCA 1. The discharges at S-39 and at S-5AS are relatively minor. During periods of low natural flow, water stored in the WCA can be released by way of the S-10 structures to the WCAs to the south to supply basins in eastern Broward and Dade Counties and Everglades National Park, by way of S-39 to supply the Hillsboro Canal basin, and by way of S-5AS to supply the L-8, S-5A, and C-51 basins.

Water Conservation Area 2A

The Water Conservation Area 2A (WCA 2A) basin has an area of 164.7 square miles and is located in south-central Palm Beach County (65.5 square miles) and in north-central Broward County (99.2 square miles).

WCA 2A and its associated Project structures have five primary functions: (1) to provide viable wetland habitat (i.e., the WCA is managed insofar as is possible as a natural Everglades system), (2) to detain and store flood and drainage water during the wet season for water supply during the dry, (3) to prevent floodwater accumulating in the Everglades from flooding urban and agricultural lands in eastern Broward County (4) to receive and store regulatory releases from Lake Okeechobee and WCA 1, and (5) to provide conveyance for water supply releases from Lake Okeechobee to eastern Broward County. Inflows to the WCA are from local rainfall, from WCA 1 by way of the S-10 structures, and from the S-7 basin by way of S-7. When required by the WCA 2A regulation schedule excess water is discharged to WCA 3A by way of the three S-11 structures, to WCA 2B by way of S-144, S-145, and S-146, to the North New River Canal basin by way of S-143, and to the C-13 and C-14 basins by way of S-38. The S-11 structures provide the principal means of discharging water from WCA 2A. The discharge at all other structures is relatively minor. During periods of low natural flow, water stored in the WCA can be released for water supply by way of the S-11 structures to basins in eastern Broward and Dade Counties and to Everglades National Park, by way of S-143 to the North New River Canal basin, and by way of S-38 to the C-13 and C-14 basins. Additional outflows from the WCA are to the C-14 basin and to the Hillsboro Canal basin by seepage through L-36 to the L-36 borrow canal.

Water Conservation Area 2B

The Water Conservation Area 2B (WCA 2B) basin has an area of 43.8 square miles and is located central Broward County

WCA 2B and its associated Project structures have five primary functions: (1) to provide viable wetland habitat (i.e., the WCA is managed insofar as is possible as a natural Everglades system, (2) to recharge regional groundwater (i.e., the Biscayne Aquifer), (3) to supply water to adjacent basins in Broward County, (4) to receive and store regulatory discharges from WCA 2A, and (5) to prevent floodwater accumulating in the Everglades from flooding urban and agricultural lands in eastern Broward County. Rainfall is the primary source of water to WCA 2B, but water can be supplied from WCA 3A as necessary to maintain WCA 2B as a wetland. There is not a regulation schedule for WCA 2B, but as a rule of thumb, when the water level in the WCA exceeds about 10.0 ft NGVD, excess water is discharged to the North New River Canal by way of S-141 if the extra discharge will not cause flooding in the North New River Canal basin. During periods of low natural flow and if the water is available in WCA 2B, water can be supplied to the North New River Canal by way of S-141 as needed to maintain the optimum stage in the canal.

Water Conservation Area 3A

The Water Conservation Area (WCA) 3A basin has an area of 767.3 square miles and is located in western Broward County (568.4 square miles) and in north-western Dade County (198.9 square miles).

WCA 3A and its associated structures have five primary functions: (1) to provide viable wetland habitat (i.e., the WCA is managed insofar as possible as a natural Everglades system), (2) to detain and store flood and drainage water during the wet season for water supply during the dry season, (3) to prevent floodwater accumulating in the Everglades from flooding urban and agricultural lands in eastern Dade County, (4) to receive and store regulatory releases from Lake Okeechobee and WCA 2A, and (5) to provide conveyance for water supply releases from Lake Okeechobee to eastern Dade County and Everglades National Park (ENP). Inflows to the WCA are from local rainfall, from WCA 2A by way of the S-11 structures, from the S-8 basin by way of S-8, from the S-7 basin by way of S-150, from the L-28 borrow canal by way of S-140, from the L-3 borrow canal by way of G-155, from the Feeder Canal basin by way of the L-28 Interceptor borrow canal, from the L-28 Gap basin by way of sheet flow through the L-28 gap and by way of the L-28 Tieback Levee borrow canal, from the North New River Canal by way of G-123 and S-142, from the C-11 basin by way of S-9, and from the area between L-38E and L-38W by way of G-64. When required by the WCA 3A regulation schedule, excess water can be discharged to ENP by way of the S-12 structures and S-333, to the Tamiami Canal by way of the S-343 structures, to WCA 3B by way of S-151, and to the Big Cypress National Preserve by way of S-344. The S-12 structures, S-333, and S-151 provide the principal means of discharging water from WCA 3A. Discharges at the other structures are minor in comparison. During periods of low natural flow, water stored in the WCA can be released for water supply to ENP by way of the S-12 structures and S-333, to basins in southeast Dade County by way of S-333 and S-151, to WCA 3B by way of S-151, and to the Big Cypress National Preserve by way of S-344. Additional outflows of water from the WCA are to the C-11 basin by way of seepage through L-37 to the L-37 borrow canal.

Water Conservation Area 3B

The Water Conservation Area 3B (WCA 3B) basin has an area of 153.6 square miles and is located in south-central Broward County (30.5 square miles) and in north-central Dade County (123.1 square miles).

WCA 3B and its associated Project structures have seven primary functions: (1) to provide viable wetlands habitat (i.e., the WCA is managed insofar as is possible as a natural Everglades system), (2) to recharge regional groundwater (i.e., the Biscayne Aquifer), (3) to supply water to adjacent basins in Dade County, (4) to provide conveyance for water supply releases from Lake Okeechobee and WCA 3A to eastern Dade County and southeastern Everglades National Park, (5) to receive and store regulatory discharges from WCA 3A, (6) to prevent floodwater accumulating in the Everglades from flooding urban and agricultural lands in eastern Dade County, and (7) when WCA 3B can not store the regulatory discharges from WCA 3A, to provide conveyance for the discharges through the WCA for subsequent discharge to tidewater. Rainfall is the primary source of water to WCA 3B, but water can be supplied from WCA 3A or Lake Okeechobee by way of C-123 (i.e., the and S-151 as necessary to maintain WCA 3B as a wetland. Water supply releases from WCA 3A or Lake Okeechobee to eastern Dade County and southeastern ENP are passed through WCA 3B by way of C-304 (i.e., the Project name for the Maimi Canal in WCA 3B). Regulatory releases from WCA 3A are made to WCA 3B by way of S-151. These releases are stored in WCA 3B when capacity is available; otherwise, they are routed through WCA 3B to C-6 (i.e., the Project name for the Miami Canal east of WCA 3B) by way of C-304 and S-31. There is not a regulation schedule for WCA 3B, but as a rule of thumb, when the water level in the WCA exceeds about 9.5 ft NGVD, excess water is discharged to C-6.

Everglades National Park

The Everglades National Park (ENP) has an area of 1684.5 square miles and is located in western Dade County (886.5 square miles), in northwestern Monroe County (773.9 square miles), and southwestern Collier County (24.1 square miles).

Project structures are largely peripheral to the park and have as their primary function supply of water to the park. Only four Project structures are within the park: L-67 Extension , S-346 and S-347, and the plug in the Buttonwood Canal. The L-67 Extension borrow canal serves as a "get away channel" for discharges from the S-12 structures. A get away channel allows water to move away from the outlet structure so that the tailwater stage at the structure does not rise high enough to prevent effective discharge of water through the structure. The plug in the Buttonwood Canal (at the boat basin in Flamingo) serves as a barrier to prevent very saline water in Florida Bay from moving up the Buttonwood Canal to Coot Bay.

Inflows to the ENP basin are from local rainfall, from WCA 3A to Shark River Slough in ENP by way of the S-12 structures and S-333, from the L-31W borrow canal to Taylor Slough by way of S-332 and S-175, and from C-111 to the South Unit of the East Everglades Wildlife Management Area and to the Panhandle of the Park by way of gaps in the south berm of C-111 between S-18C and S-197.

Water supply to Shark River Slough is determined as a function of rainfall evaporation, and the stage in WCA 3A and the previous week's discharge. Discharge amounts are calculated on a week to week basis. Insofar as is possible, forty-five percent of the total calculated discharge is released to Shark River Slough on the west side of L-67 Extension by way of the S-12 structures. The remaining fifty-five percent is discharged to Northeast Shark River Slough by way of S-333 and the L-29 borrow canal. Flow passes from the L-29 borrow canal to the slough by way of culverts under U. S. Highway 41 between L-67 Extension and L-30. Water supply to Taylor Slough and to the Panhandle of the Park is required by law to be at least 55,000 acre-feet for year (35,000 acre-feet to Taylor Slough and 18,000 acre-feet to the Panhandle).

South Dade Conveyance System

Purpose of the System

The South Dade Conveyance System (SDCS) was mandated by an act of Congress. Its primary purpose is to supply 55,000 acre-feet of water per year to the Everglades National Park (ENP). Under District-wide drought conditions, if the water allocated to ENP cannot be supplied from storage, the ENP receives (by way of SDCS) 16 percent of the surface water supplied to District canals south of Lake Okeechobee.

A secondary purpose of the SDCS is to supply water to South Dade County canals to maintain water table elevations at high enough stages (2.0 ft NGVD at downstream control structures) to prevent saltwater intrusions into local fresh groundwaters. Design flows for the SDCS to South Dade County canals are adequate to replace seepage losses in the canals for a 2.0 ft NGVD stage.

Another purpose of the SDCS is to supply water to the Alexander Orr and the Florida City Wellfields. Placement of a wellfield near the intersection of C-1 and the L-31N borrow canal is being considered. SDCS would also supply this wellfield.

Description of the System and Its Operation

The South Dade Conveyance System (SDCS) supplies water to Everglades National Park (ENP) at all times and to District canals (C-6, C-4, C-1, C-102, C-103, C-113, and C-111) in Dade County during conditions of low natural flow. A schematic map of the SDCS is shown in Figure 38.

The system was built using existing Project canals and structures. C-304, the L-30 borrow canal and the L-31N borrow canal were enlarged. S-151 was enlarged and S-335 was changed from 2 - 72 inch corrugated metal pipes to a gated spillway. Only S-336,S-337, and S-338 were constructed for the SDCS.

Under design conditions (1-10 year drought) water is released to the SDCS from storage in Water Conservation Area 3A at a stage of 7.5 ft NGVD. The design discharge is 1955 cfs. This discharge includes the amount allocated to ENP, the amount required to replace seepage losses in South Dade County canals, and the amount required to recharge the Alexander Orr and the Florida City Wellfields. 1350 cfs is discharged at S-333 into the L-29 borrow canal ,and 605 cfs is discharged at S-337 into the L-30 borrow canal.

The water discharged at S-333 is conveyed to the east by the L-29 borrow canal to S-334 at the intersection of the L-29 borrow canal and the L-30 borrow canal. The design tailwater stage at S-333 is 7.0 ft NGVD, and the design headwater stage at S-334 is 5.0 ft NGVD. 120 cfs of the 1350 cfs entering the L-29 borrow canal at S-333 is lost to flow to the south through culverts under U.S. Highway 41 between S-333 and S-334. 1230 cfs is discharged to the L-30 borrow canal from the L-29 borrow canal via structure S-334.

605 cfs is discharged by S-337 to the L-30 borrow canal. Flow in the L-30 borrow canal is to the south to S-335, just north of the intersection of the L-30 borrow canal with the L-29 borrow canal and C-4. 105 cfs are expected to be lost to seepage in the L-30 borrow canal between S-337 and S-335.

South of S-335, the 500 cfs from the L-30 borrow canal joins the 1230 cfs from the L-29 borrow canal. The combined discharge of 1730 cfs flows south in the L-31N borrow canal at a beginning stage of 4.7 ft NGVD. 145 cfs of this flow is discharged east through S-336 to C-4 for recharge of the Alexander Orr Wellfield east of C-2, 305 cfs is discharged to C-1, and 120 cfs is lost to seepage upstream of S-173. The headwater stage at S-173 is 3.0 ft NGVD. During drought flow S-173 is closed and the pump station, S-331, is used to raise the tailwater stage at S-173 to 6.0 ft NGVD. Between S-173 and the intersection of the L-31N borrow canal with the L-31W borrow canal, 260 cfs is supplied to C-102 at a stage of 5.4 ft NGVD, 210 cfs is supplied to C-103 at a stage of 4.7 ft NGVD, and approximately 205 cfs is lost to seepage. 485 cfs are left to be divided between the C-111 canal to the south and the L-31W borrow canal to the west.

210 cfs is discharged to the L-31W borrow canal by way of S-174. 160 cfs (37,000 acre-feet per year) is pumped to Taylor Slough by S-332. Any remaining flow, not lost to seepage, is discharged to the ENP through S-175.

275 cfs is discharged to C-111 from the L-31N borrow canal by structure S-176. The tailwater stage at S-176 is 3.0 ft NGV. South of 176, 140 cfs is supplied to C-113 (to recharge the Florida City Wellfield), 60 cfs is lost to seepage and 75 cfs (18,000 acre-feet per year) is discharged through S-18C at a stage of 2.0 ft NGVD. This flow is discharged to the pan handle portion of ENP through gaps in the south berm of C-111 between S-18C and S-197.

A summary of the design flows and stages in the SDCS is given in Table A-1.

TABLE A-1 South Dade Conveyance System
Design Flows and Stages

		Stage (ft NGVD)	Discharge (cg
L-29 @ S-333		7.0	1,350
L-20 @ S-334		5.0	1,230
L-30 @ S-337		5.2	605
L-30 @ S-335	upstream downstream	5.0 4.8	525 525
L-30 @ L-29 or L-31N		4.7	500
L-31N @ US 41		4.7	1,585
L-31N @ C-1	upstream downstream	3.5 3.5	1,490 1,185
L-31N @ S-331	upstream downstream	3.0 6.0	1,160 1,160
L-31N @ C-102	upstream downstream	5.4 5.4	1,115 855
L-31N @ C-103	upstream downstream	4.7 4.7	740 530
L-31N @ S-174	upstream downstream	4.6 3.1	485 210
L-31N @ S-176	upstream	4.6	275
C-111 @ S-176	downstream	3.0	275
C-111 @ C-113	upstream downstream	3.0 3.0	275 135
C-111 @ S-177	upstream downstream	3.0 2.0	135 135
C-111 @ C-111E	upstream downstream	2.0 2.0	97 97
C-111 @ C-18C	upstream downstream	2.0 1.4	75 75

Water Supply to the Caloosahatchee River

LaBelle and Ft. Myers obtain their water supply from the Caloosahatchee River. In the case of Ft. Myers, water is not only pumped from the Caloosahatchee to their wellfield, but additional water has to be released from time to time to eliminate salinity problems at the intake upstream of the Franklin Lock.

Several large groves on the south side of the Caloosahatchee get irrigation water from the canal. The Flaghole Drainage District gets their water supply from Lake Hicpochee which is a part of the Caloosahatchee River.

Water Supply to the St. Lucie Canal

The Florida Power & Light reservoir is maintained by water pumped from the St. Lucie Canal; however, the major demand on the St. Lucie Canal water will come from the thousands of acres of citrus groves along the banks of the canal. The St. Lucie Estuary Management Plan adopted by the District will require pulse releases from Lake Okeechobee when the salinity in the estuary is below 12 ppt during the period from April through July depending on Lake stages. .

APPENDIX 2

SUPPORTING DATA

Upper System Month End Stage/Storage (8/31/88-8/31/89)
Source = Systems Storage Report

1988-89	Lake Myrtle (S-57HW) Stage	Storage	Lake Alligator(S-58HW) Stage	Storage	Lake Mary Jane (S-62HW) Stage	Storage	Lake Gentry (S-63HW) Stage	Storage
August	61.06	8670	63.24	52180	60.11	22185	60.79	15682
September	60.87	8370	63.13	51410	60.03	21905	60.97	15999
October	61.16	8870	63.04	50780	60.18	22430	61.06	16152
November	61.74	9880	63.28	52460	60.95	25125	61.19	16382
December	61.15	8850	63.25	52250	60.92	25020	61.30	16580
January	61.31	9115	63.63	54910	61.17	25963	61.49	16903
February	60.84	8340	63.46	53720	60.80	24600	61.34	16648
March	60.68	8120	63.45	53650	60.64	24040	60.86	15808
April	60.16	7410	62.81	49417	60.13	22255	60.34	14892
May	59.62	6670	62.16	45712	59.55	20450	59.55	13560
June	59.70	6750	62.09	45313	59.62	20660	59.67	13752
July	59.95	7100	62.12	45484	59.76	21080	60.35	14910
August	61.08	8710	63.34	52880	60.14	22290	61.02	16084

1988-89	East Lake Tohopekaliga Stage	Storage	Lake Tohopekaliga Stage	Storage	Lake Kissimmee Stage	Storage	Lake Istokpoga Stage	Storage	Total Upper System Storage
August	56.65	108975	53.85	123575	50.54	339704	38.63	161956	832927
September	56.82	110930	53.68	120280	51.57	392494	39.25	179510	900898
October	56.87	111505	53.68	120260	51.63	395746	39.10	175230	900973
November	57.93	124904	54.88	144540	51.87	408754	39.23	178938	960983
December	57.93	124904	55.02	147440	52.46	445332	39.16	176940	997316
January	58.22	128594	55.06	148320	52.61	454962	39.28	180368	1019135
February	57.75	122600	54.59	138595	51.92	411464	39.08	174660	950627
March	57.38	117864	54.28	132240	51.33	379486	38.98	171816	903024
April	56.26	104490	53.37	114215	50.01	314476	38.44	157808	784963
May	55.10	91600	52.07	89795	49.08	273244	37.53	131134	672165
June	55.36	94460	52.04	89240	48.90	266350	37.23	122784	659309
July	55.40	94900	52.35	94975	49.04	271472	37.45	128905	678826
August	56.63	108745	53.56	117920	49.35	285205	38.11	147311	759145

Lower System Month End Stage/Storage (8/31/88-8/31/89)
Source = Systems Storage Report

	Lake Okeechobee (10-gage avg.)		WCA-1		WCA-2A		WCA-3A		Total Lower
1988-89	Stage	Storage	Stage	Storage	Stage	Storage	Stage	Storage	System Storage
August	15.93	4393850	15.76	135280	13.15	218200	10.90	1184000	5931330
September	15.87	4367150	15.40	99200	12.18	118160	10.48	1006600	5591110
October	15.03	3993350	13.78	22776	11.71	80344	9.92	759040	4855510
November	14.87	3921110	13.36	16492	11.48	65428	9.62	613760	4616790
December	14.42	3717260	13.17	14302	11.15	50150	9.08	396480	4178192
January	14.10	3572300	12.13	6998	10.85	38900	8.75	293000	3911198
February	13.33	3246270	10.94	3068	10.25	21700	8.18	162960	3433998
March	13.18	3183420	13.10	13560	9.83	16849	7.96	126160	3339989
April	12.92	3077120	13.87	24504	9.72	15579	7.50	66000	3183203
May	12.09	2756740	10.82	2804	9.93	18004	6.02	11960	2789508
June	11.21	2440760	11.52	4668	10.55	29500	7.30	48800	2523728
July	11.21	2440760	13.74	22040	10.75	35500	8.10	149200	2647500
August	11.42	2515520	15.61	119440	11.63	75032	8.33	191960	2901952

Lake Okeechobee Inflows (Acre-feet)

1988-89	S-65E	Fisheating Creek	Indian Prairie*	Taylor Creek/ Nubbin Slough	Other Inflows**	Rainfall
September	132710	18649	32824	4804	8927	48168
October	2862	704	7459	962	3183	25125
November	345	1632	4940	1359	7581	119189
December	0	1369	2449	492	1476	32889
January	32589	664	972	502	6724	35479
February	55292	357	448	173	10402	10152
March	63351	1388	12004	1192	56129	91739
April	90713	264	10711	1113	5148	161613
May	68086	46	20065	0	9601	58234
June	-916	0	1162	0	18806	128079
July	9715	2574	10111	1438	43633	138278
August	13135	29774	13970	3945	80258	162971
Totals	469714	57421	117115	15980	1011916	251868

*Indian Prairie = S-71, S-72 and S-84
**Other Inflows = S-127, S-129, S-133, S-135, S-4, S-235, S-2, S-3, S-77 S-308, L-8 @441 and Agricultural inflows

Lake Okeechobee Outflows (Acre-feet)

1988-89	Lower East Coast	Everglades Agricultural Area	S-308	S-77	Other Outflows*	ET
September	1416	38356	4859	7912	15513	198886
October	101	80030	13992	23187	2364	184500
November	29393	52145	7707	2577	10647	125541
December	7936	71602	5110	5770	12620	104578
January	5798	54335	12288	10055	6999	117791
February	40388	85721	30152	30227	12077	143478
March	43673	74521	10739	4810	10236	146231
April	47685	67581	28213	31135	9465	183995
May	60626	124544	13127	23326	9826	231016
June	43105	127245	0	9199	5952	189890
July	16114	11684	208	9281	8390	156870
August	7577	2482	3967	63472	7600	156870
Totals	303812	790246	130362	220951	111689	1939644

*Other Outflows = C-51 and the M-Canal

Water Conservation Area 1 Inflows (Acre-feet)
September 1988 - August 1989

Month	S-5A	S-6	Rainfall
September	10353	3205	9223
October	0	0	1987
November	7466	0	1473
December	13613	3041	360
January	10747	0	344
February	14835	817	465
March	18734	0	2546
April	7486	4207	1917
May	7139	2614	682
June	18704	0	770
July	36698	2037	2706
August	39720	27150	13763
Totals	185495	43071	36237

Water Conservation Area 1 Outflows (Acre-feet)

Month	ET	SEEPAGE	S-10	S-39	L-40	S-5A
September	33626	13216	1067	9348	2690	1056
October	23939	9907	0	4564	10604	6774
November	3634	5353	0	2949	9717	143
December	2980	3055	0	7466	0	0
January	2130	1497	0	8636	20720	0
February	1478	875	0	12934	22951	10
March	9569	6297	0	8656	0	0
April	3349	2261	0	8533	6661	6653
May	3179	0	0	8666	3930	4261
June	967	0	0	4915	889	18268
July	2939	0	0	1515	1345	26273
August	11282	729	0	1551	948	0
Totals	99072	43190	1067	79733	80455	63438

Water Conservation Area 2A Inflows (Acre-feet)
September 1988 - August 1989

Month	S-7	S-10	Rainfall
September	3017	1067	12004
October	0	0	3889
November	4596	0	9520
December	1367	0	230
January	2737	0	692
February	4268	0	242
March	0	0	777
April	192	0	761
May	3629	0	718
June	10932	0	1634
July	9010	0	4676
August	18852	0	5319
Totals	58600	1067	40461

Water Conservation Area 2A Outflows (Acre-feet)

Month	S-11	S-34	S-38	SEEPAGE	ET
September	81002	0	6589	13439	47031
October	0	0	2581	11567	42690
November	0	0	712	10430	19516
December	0	0	2156	9327	9789
January	0	1063	1839	8324	2988
February	0	2973	3106	6853	2872
March	0	137	2834	6218	2961
April	0	5189	2938	2607	1664
May	0	4683	4239	4078	2805
June	0	3437	3098	5549	2291
July	0	0	432	7221	3879
August	0	0	399	7722	4352
Totals	81002	17482	30923	93335	142838